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telecommunication journal

MONTHLY MAGAZINE OF THE INTERNATIONAL TELECOMMUNICATION UNION — FEBRUARY 1982

special optical fibres

WORLDWIDE BANK TO USE NEDIX-510F PACKET SWITCHING SYSTEMS

The Sumitomo Bank, Limited will use four NEDIX-510F packet switching systems to enhance their telephone, facsimile, teletype and on-line computer operations. The systems are being installed in New York, Tokyo, Hong Kong and London.

Designed to be the core of NEC's Integrated Voice/Data Communications Systems, the NEDIX-510F can packetize digital data (including voice data from digital telephones), then multiplex and transmit them over leased or dedicated lines—or a switched telephone or telex network—at speeds from 50bps to 64kbps. For optimal use of transmission lines the system provides both real-time and store-and-forward switching.

Packet terminals, non-packet terminals, host computers of different speeds and protocols—all can be linked to communicate with each other through the NEDIX-510F. Each packet terminal can communicate with up to 1,024 other terminals simultaneously over one physical line. Modular hardware and software and a wide range of network components simplify the building of a network structure according to user requirements.

The NEDIX-510F meets CCITT Recommendations and fully complies with other international and national standards. It is a prime example of how NEC integrates computer and communications (C & C) technologies to create a comprehensive information network.

NUMBER 121

SINGLE-CHIP MICROCOMPUTER HAS BUILT-IN A/D CONVERTER

For the first time ever, a microcomputer incorporates counters, timers, a serial interface, an A/D converter, a 4K-byte ROM and a 256-byte RAM on a single chip.

NEC's new μCOM-87AD (μPD7811G) is an 8-bit single-chip microcomputer with a built-in analog-digital converter for such applications as process control, copying machines, and automobiles. When used in automobiles, for instance, it can convert eight kinds of analog information (such as temperature, pressure, and power supply) into digital information for further processing by the on-chip A/D converter.

The μCOM-87AD offers a high speed conversion rate of 50μs. And use of the "successive approximation technique" gives it better cost-performance.

Another outstanding feature is its ability to perform pulse width measurement and frequency counting as well as programmable rectangular waveform output without need of complicated software. This makes it ideal for real-time control applications.

Other features include: Software performance 1.5 to 5 times higher than most other 8-bit single-chip microcomputers; A unique double-buffered serial interface which makes possible a multiprocessor system configuration; Direct addressability of external ROMs and RAMs up to a total of 60K bytes.

NEW MODEMS OFFER THE FASTEST POLLING RESPONSE TIME

Two new polling modems from NEC offer the world's fastest polling response time.

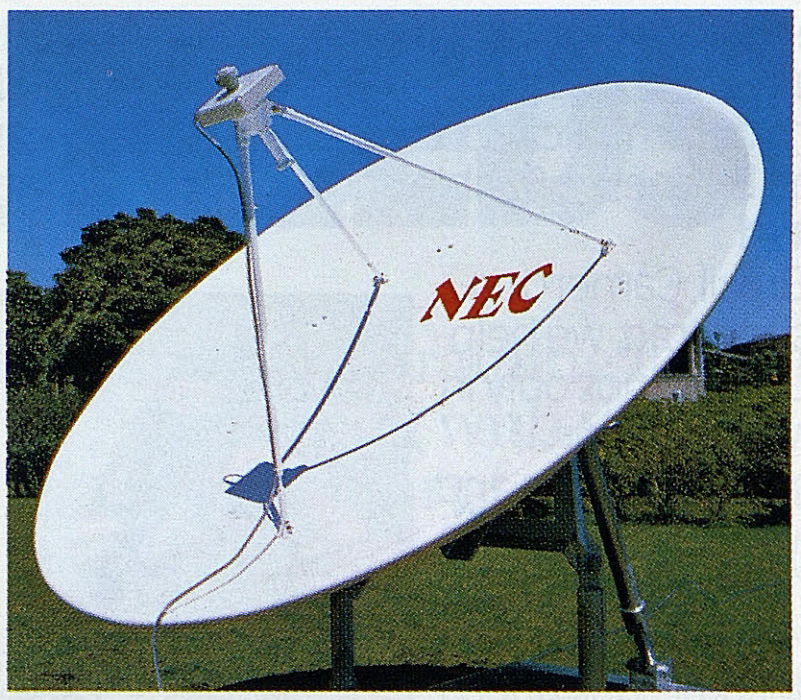
The 9,600bps data modem SP9600 FAST and the 4,800bps data modem SP4800 FAST incorporate a unique equalizer to offer a response time of 15msec. Even if synchronism is lost during data transmission (due to temporary circuit malfunction) this automatic equalizer quickly recovers without training signals because of a retrain-on-data function. And these two models are only about 1/3 the size of competing products thanks to extensive use of LSIs.

Another new model, the 2,400bps data modem SP2400 FAST, is about half the size of comparable modems. It has a polling response time of 7msec, and is designed to meet CCITT's V.26 and V.26 bis recommendations.

All three modems can be used over leased circuits or the public switched telephone network.

NEW GENERATION 12GHz TVROs

With an antenna diameter of only 1.8m, NEC's 861 Series TVROs are economical and easy to install. They are designed to offer excellent reception of OTS-2 and future systems (such as ANIK-C), and are ideal for CATV stations, rebroadcasting and community reception.



Featuring an impressive G/T of 18.7 dB/K, the 861 Series can pull in clear signals even from relatively low power satellites. And NEC TVROs can access any polarization of satellites without extra cost. The outdoor units have an advanced but simple design that will permit easy manual change-over when satellites convert from linear to circular polarization in the future.

The 861 Series has a wide-band antenna—11.50 to 12.75GHz. The low noise converter, based on an NEC-developed GaAs FET, is rated at 360 degrees K. With full 24-channel reception, dual polarization capability and multi-channel reception, the 861 Series provides outstanding performance in a compact and economical package.

NEC is the world's No. 1 supplier of INTELSAT earth station systems, and has been accumulating expertise in direct TV reception from Ku-band satellites since 1973.

NEC

Nippon Electric Co.,Ltd.
P.O.Box1,Takanawa,Tokyo,Japan.

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a1

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Telephone conversations clear as a bell despite a 45,000 mile journey through space – that's the miracle of modern communications.

And that's the business of Cable and Wireless.

All over the world

From Bahrain to Brazil, Cameroon to Korea, Indonesia to Iraq, we help the world communicate not only in the 11 countries whose national telephone systems we operate and the 36 countries where we operate public international networks, but also in over 60 countries where we provide all types of communications systems.

Total telephony

Our fleet is responsible for looking after over half the world's total capacity of submarine telephone cable. We operate over 20 earth stations, more than any other user of the Intelsat system.

Unbiased advice

But Cable and Wireless is much bigger than just telephones. If you've got a communications problem of any sort, including all aspects of radio communication, it's probable that we can help. And since we're not tied to any one manufacturer, our advice will be totally unbiased.

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Cable and Wireless
helps the world communicate

Cable and Wireless Public Limited Company, Dept. ITU, Mercury House, Theobalds Road, London WC1X 8RX Tel: 01-242 4433 Telex: 23181

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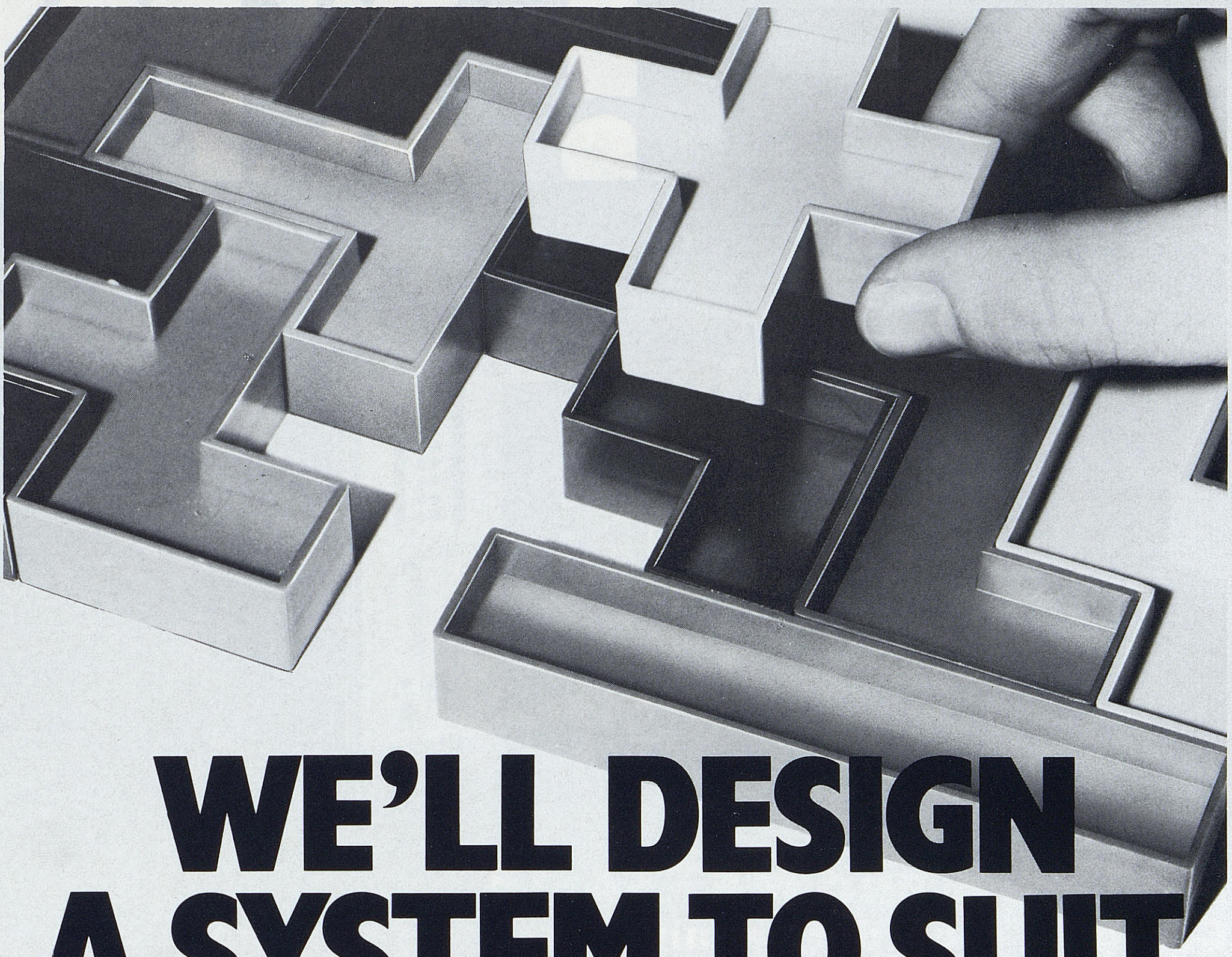

WE'LL DESIGN A SYSTEM TO SUIT YOUR NEEDS

Of course, any optical cable system is a lot more than just the hardware.

And BICC takes care to provide you with a complete package.

That includes cable and accessories, test equipment, installation, commissioning and specialist training for your staff, along with the production of an original design to fit in with your particular requirements.

So whatever application you have in mind, when you're sold on optical cables technology, let BICC sell you a system.

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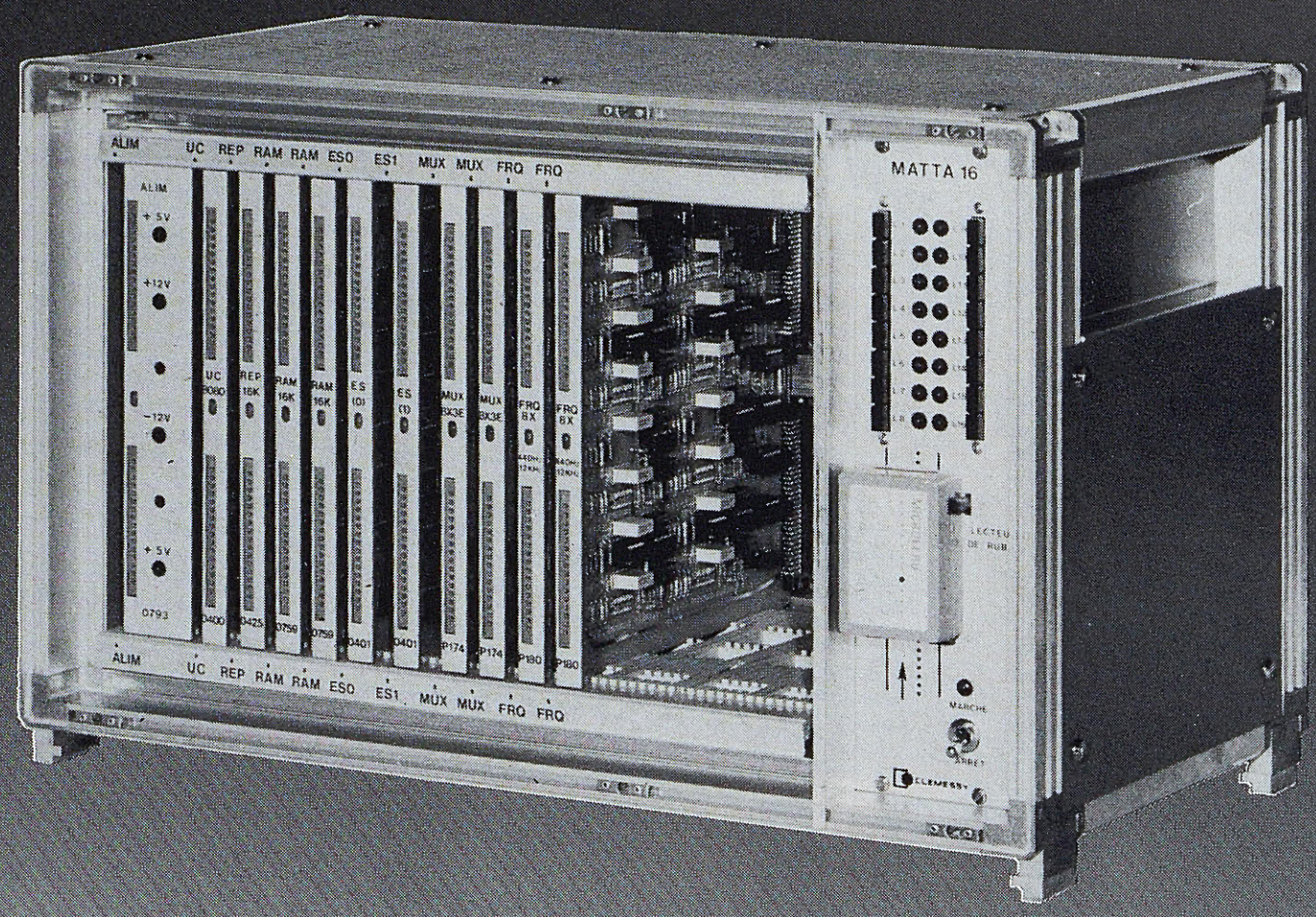


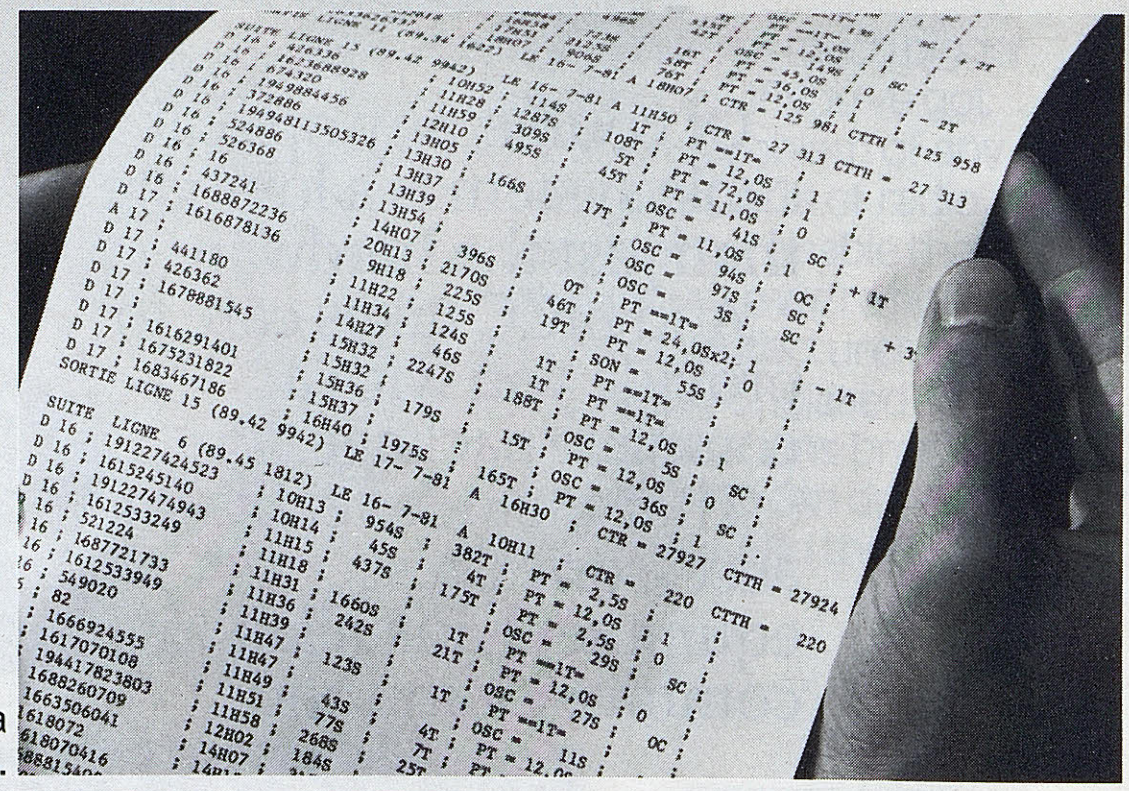
MATTA 8 and MATTA 16
Charging recorders-analyzers

MATTA 8 and MATTA 16 are charging recorders-analyzers for 8 or 16 subscriber lines. They have been designed for the two purposes of providing **charging justification** and **facilitating maintenance.** For each call, they provide the theoretical charge period and immediately calculate the positive or negative charging error. To achieve these functions, it is necessary to previously enter the national and international charging schemes into the device.

DATA PROVIDED BY THE PRINTER :

- Date and time of each call
- Number of the called telephone subscriber
- Conversation time (outgoing or incoming)
- Number of unit charges received
- Incoming ringing time
- Duration of false calls
- Holding time of unsuccessful calls
- Theoretical charge period
- Charging errors during an outgoing call
- Erroneous charges out of the conversation time
- Indication of call during full rate, reduced rate, or during a change of rate
- Indication if the 1st charge unit was received before 1/10th of the charge period

Furthermore, MATTA 8 and MATTA 16 provide a summary table of the results and of the charging errors.



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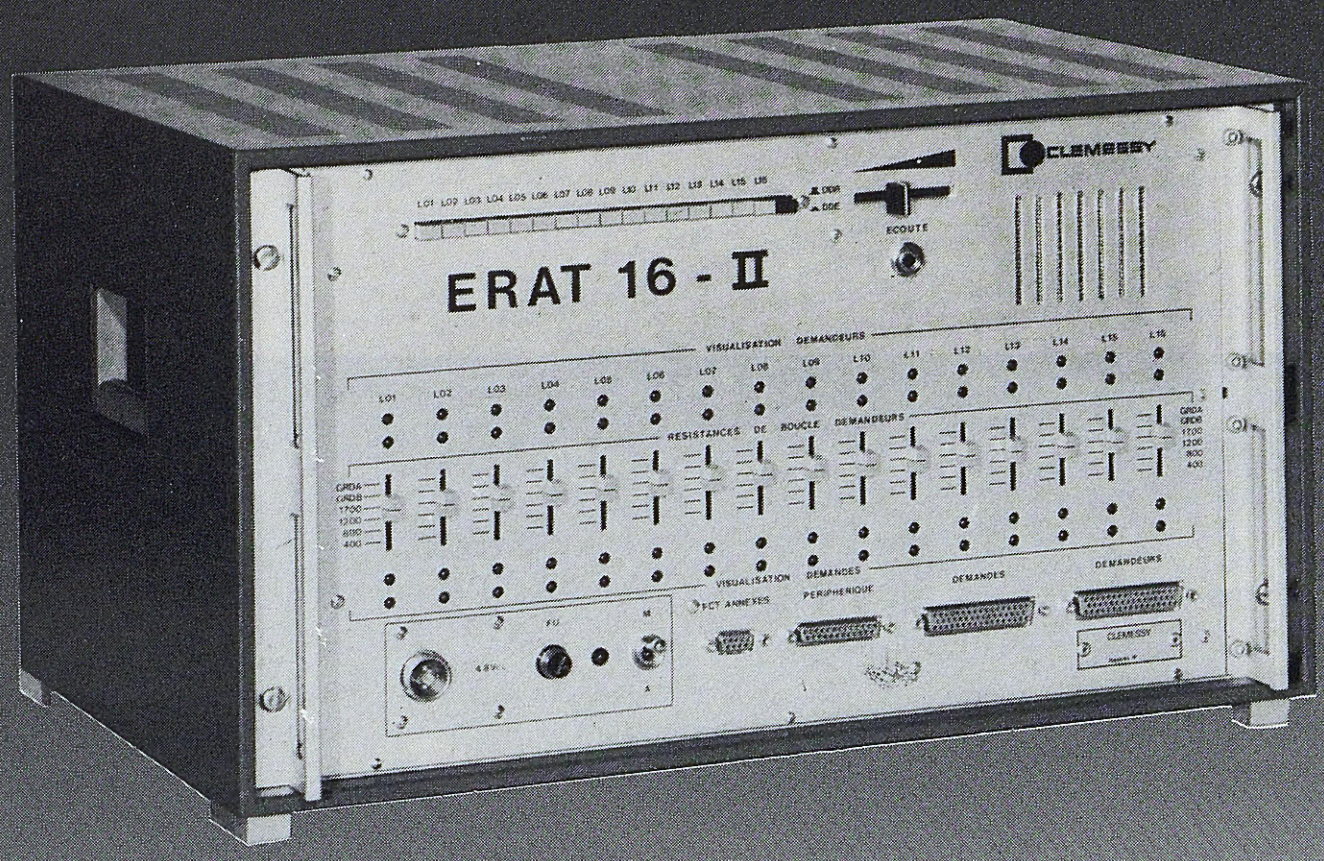


ERAT 16 II
Telephone call simulator

In order to check the correct operation of an automatic exchange, ERAT 16 II (telephone call transmitter-receiver) generates and monitors a telephone traffic of 16 simultaneous calls (capacity of up to 3000 calls per hour). A teleprinter provides the dialog with the device and makes the results available.

APPLICATIONS

- Measurement of the quality of service of an exchange
- Trouble shooting and maintenance
- Inter-exchange maintenance thanks to the «Inter/ERAT 16 II» test facility
- Possibility to call answering lines internal to ERAT 16 II, located in a remote ERAT 16 II or any other answering line

ERAT 16 II represents the 2nd generation of that type of apparatus. The vast experience acquired by CLEMESSY in the construction of ERAT devices enables us to offer them at highly competitive prices.

Specialized in the design and construction of apparatus for the maintenance of telephone exchanges, the D.A.I. division of Clemessy offers a complete range of products. Full documentation will be sent to you upon receipt of your request.

Request for documentation

Mr. .....
Function .....
Company ..... Telephone .....
Address .....
Wishes to receive documentation on the following
☐ MATTA 8 an 16 - ☐ ERAT 16 II - ☐ Other instruments

Why you need

Fujitsu's digital telex/
is the answer to all your problems

the FEDEX-100

data switching system of tomorrow. And it's here today!

The FEDEX-100 digital telex/data switching system gives you the finest in sophisticated switching performance. Developed by Fujitsu, Japan's number one computer maker and one of the world's leading telecommunications companies, the FEDEX-100 incorporates the very latest in switching and computer technologies. It can meet your current and future system requirements like no other system can. Here's why:

ADVANCED SWITCHING

The FEDEX-100's time-division switching network features an improved sampling method that provides a host of important advantages, such as distortion-free communications, reduced transfer delay, greater receive margin, and much, much more.

ABUNDANT SERVICE FEATURES

The FEDEX-100 comes with a wide range of service functions, including such sophisticated features as store-and-forward, speed and code conversion, multi-address calls, and conference calls. These and other functions will meet not only all your current switching needs, but all your new and changing requirements as well — for years to come.

EASY OPERATION/MAINTENANCE

We designed the FEDEX-100 for easy operation and maintenance. You can enter all commands by console teletypewriter or paper tape. Automatic checks ensure that entry is error-free. You also get full alarm, indication and control facilities designed for the most efficient man-machine communication.

OUTSTANDING RELIABILITY

The FEDEX-100 has been designed and produced to last. Extensive use of advanced semiconductors, many of them Fujitsu proprietary, and virtually 100% redundancy in the communications path assure you of the highest reliability. While extensive fault detection facilities make maintenance chores easier than ever before.

BUILDING-BLOCK CONSTRUCTION

The FEDEX-100's modular design allows you to start out small and grow as big as you want — all the way up to a 48,000-line processing capability. You keep costs down by paying as you grow. And because of the state-of-the-art semiconductor technology incorporated throughout the FEDEX-100, your floor-space requirements will be minimal. Your power consumption requirements too.

EFFICIENT OPERATION

The incorporation of LSIs, the modular construction design, the extensive redundancy and the inclusion of the remote line concentrator option, all combine to give you the ultimate in operating efficiency. Which means that when you operate the FEDEX-100, you save money. While providing your customers with services they've never even dreamed of before.

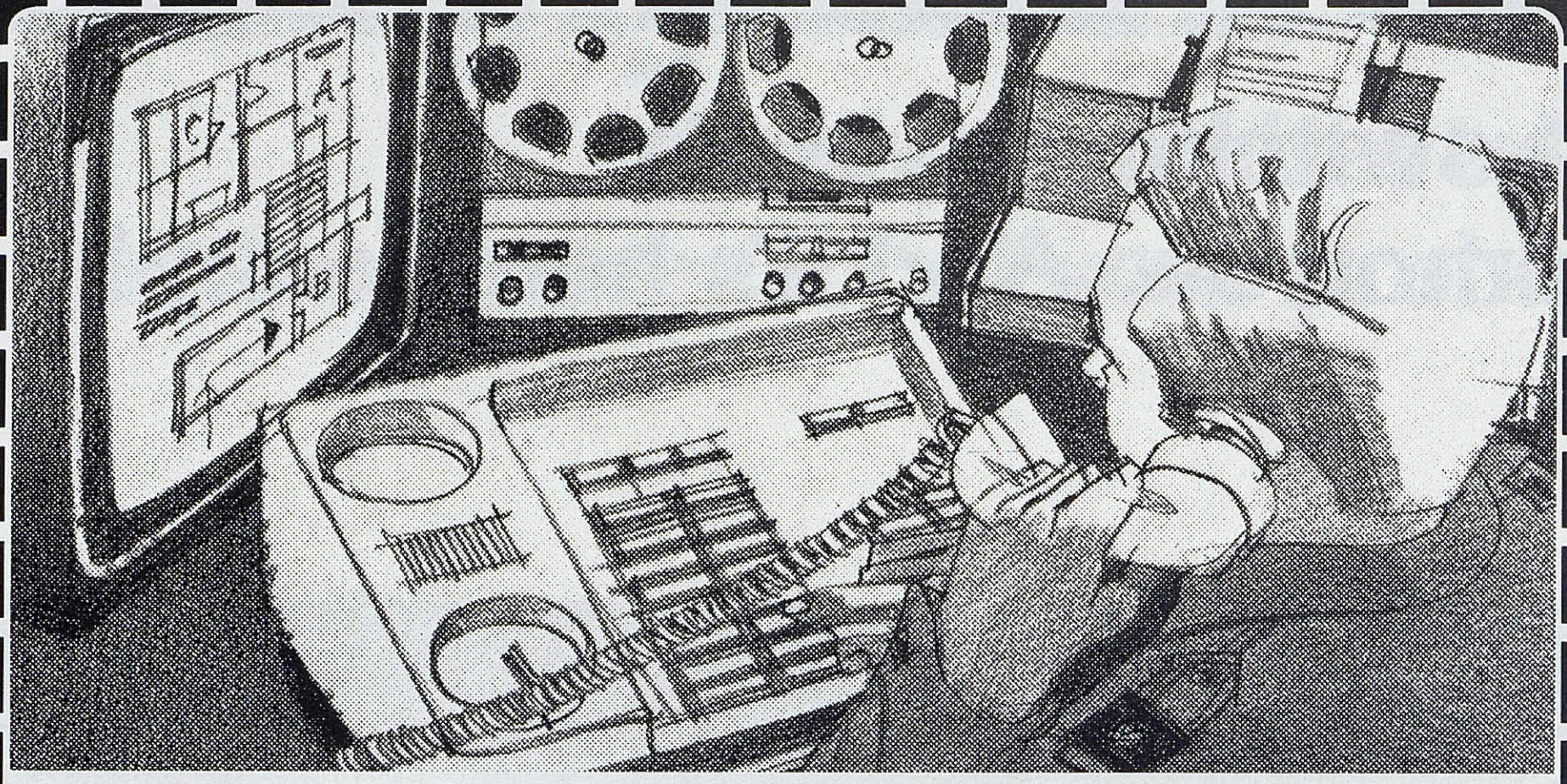
The FEDEX-100 from Fujitsu. The digital telex/data switching system of tomorrow, here today. For more information write to Fujitsu soon.

DIGITAL NETWORKS

FUJITSU

Fujitsu Limited: 6-1, Marunouchi 2-chome, Chiyoda-ku, Tokyo 100, Japan Telephone: 03-216-3211, Telex: J22833

Main Products • Switching Systems • Carrier & Radio Systems • Computer Systems • Data Communications Systems • Semiconductors • Electronic Components



If you want an alarm or mobilisation system that really works, contact Autophon.

It's worth it.

We are interested in finding out why a user can feel more secure with an Autophon alarm transmission system.

☐ Please send details on the TUS audio frequency transmission system which transmits alarm signals on existing public telephone lines.

☐ Let us know more about the advantages of the SMT system with which intervention teams or individuals can be selectively mobilized via telephone subscriber lines, even if the respective number is busy.

☐ We are interested in a combined TUS/SMT system.

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JT.

Send to Autophon AG, International Division, Steinstrasse 21, CH-8036 Zurich/Switzerland

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Téléphonie SA in Lausanne, Sion, Geneva

AUTOPHON

Speak to Autophon
when you need to give or receive information, if you want to communicate verbally or visually,
when you need the right connection with or without wiring,
when you need to give warning, supervise, or be ready for action.

MANUAL SWITCHBOARDS
– an alternative in rural areas

- Do you want to provide rural areas with telephone service?
- Have you difficulty in getting hold of skilled staff?
- Have you normally long and badly insulated lines?
- Do you need a system that almost anyone can install, operate and maintain?
- Do you want an operator to help people and get the most out of your trunk lines?
- Are you without electricity entirely or at times?
- Do you need a low-price solution?

If your answers are yes, don't be surprised. Many HAVE HAD the same problems and BOUGHT Ericsson MODERN MAGNETO SWITCHBOARDS.

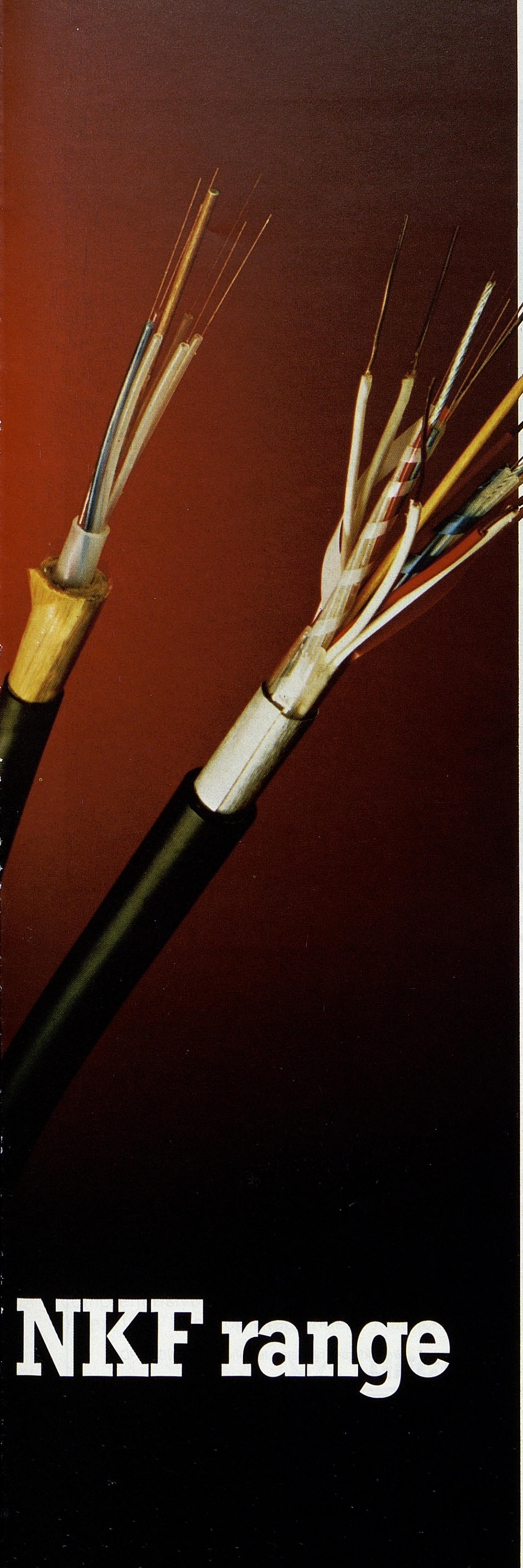
LM ERICSSON'S MODERN MAGNETO SWITCHBOARD FOR 10–240 LINES.

- Compact, space-saving and modern with all equipment located inside the desk-top cabinet.
- Advanced traffic and operator facilities.

ERICSSON

Telefonaktiebolaget LM Ericsson, Telephone Exchange Division, S-126 25 Stockholm, Sweden

40 optical cables from the



NKF range

Of course, only 6 are shown, but covering at least 40 applications in many industries.

Why so few cables for so many applications?

Simple.

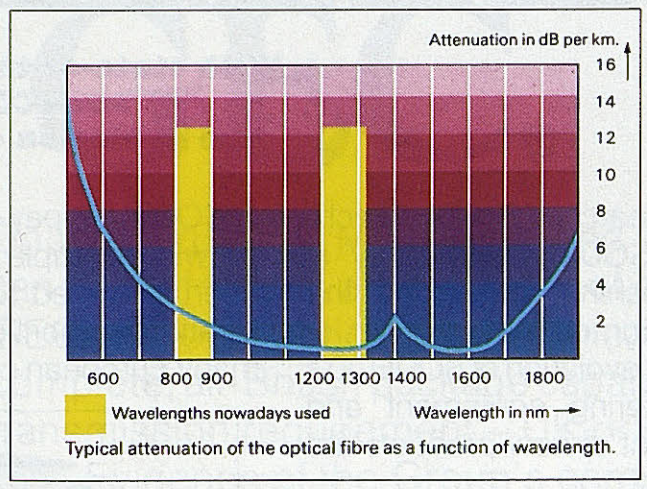
They have all the same principle of loose tube fibre protection, so we can offer higher quality through specialization.

We use a glass fibre which is manufactured by the unique Philips PCVD process. It's internationally acknowledged as one of the best in the world.

And we use every one of our 70 years experience in cable manufacture.

Whether your requirements are for metal free or steel core cables, for direct buried, duct or aerial cables, for hybrid or pure fibre cables, regardless the number of fibres, – whatever your needs are – NKF will deliver to your specification, and give you the same unbeatable quality.

We'll install under any conditions you can think of, still giving you years of trouble-free operation and performance figures less than 3 dB/km attenuation and over 1 GHz bandwith over 1 km at 850 nm and less than 1 dB/km at 1300 and 1600 nm.



Typical attenuation of the optical fibre as a function of wavelength.

NKF

Member of the Philips group of companies.

We simply connect people

NKF Telecommunication Cable Systems, P.O. Box 85, 2740 AB Waddinxveen, the Netherlands, phone +3118288122, telex 20585 nkft nl.

With state-of-the-art technologies SODECO shares in the evolution of the telephone.

Continually searching for new technologies, the SODECO of today is putting the finishing touches to the installations of tomorrow.

The constant evolution of SODECO's telephone metering equipment and the development of new products are continuing proof.

For example, the pre-paid holographic card (an exclusive SODECO technology) is already replacing coin operation in certain installations.

This is how we are getting ready for the future of the telephone.

SODECO pay-phones with simple or with multiple functions, all have been designed following telecommunication authorities' specifications. In many European countries, and throughout the world.

Prepaid card operated telephone PHONOCARD

Then, SODECO's telephone charge meters fulfil users' requirements as well as those of telecommunications authorities. From simple counters to electronic installations equipped with printers, our devices record the cost and, depending on the model, can control, provide breakdowns and reinvoice telephone charges.

SODECO equipment adapts to most existing telephone systems and is already installed in more than 30 countries.

SODECO-SAIA Grand-Pré 70 CH-1211 Geneva 16 (Switzerland) Tel. 022 - 33 55 00 Telex 22 333
A company of the Landis & Gyr group with representatives throughout the whole world.

LANDIS & GYR
SODECO

In this age of grandiose names, we call ourselves GEC Optical Fibres... because we sell optical fibres

and because we are GEC.

At the risk of sounding a little obvious, we've always believed it makes more sense to tell our customers from the very outset who we are and what we make. That's why we changed our name from London Electric Wire (the Company made electric wires as long ago as 1879) to GEC Optical Fibres.

And if this recent change makes us sound like one of the 'newer boys' in the fibre business, let's put that ghost to rest as well. We took up the processes that GEC Hirst Research Centre began developing 12 years ago, to become the GEC Group's total Production Unit for Optical Fibres.

Today, we make and sell one of the most comprehensive range of fibres in the world. Graded Index Low Loss or Step Index. Plastic-Clad and Double Crucible. Multimode and Monomode. You can order from us a single reel of fibre. Or, through GEC, a total optical communications system; a complete, all-British package capable of meeting any transmission requirement – UK or overseas.

Evidence of the Group's complete capability in optics – and its commitment to this growing technology – lies in our extensive contribution to British Telecom's vast new telecommunications network. In this project alone, we've contributed many thousands of kilometres of high-performance, low-loss fibre.

If you feel we can be of help on any optical communication project or problem, contact us.

We're keen to live up to our name.

GEC OPTICAL FIBRES

GEC Optical Fibres, 210 Church Road, Leyton E10 7JH.
Telephone: 01-539 3636 Telex: 23750

Looking at Fibre Optics?

Then look at STC.

The technology involved in STC's current contracts for the installation of optical systems is laying the foundation for the networks of the 21st century.

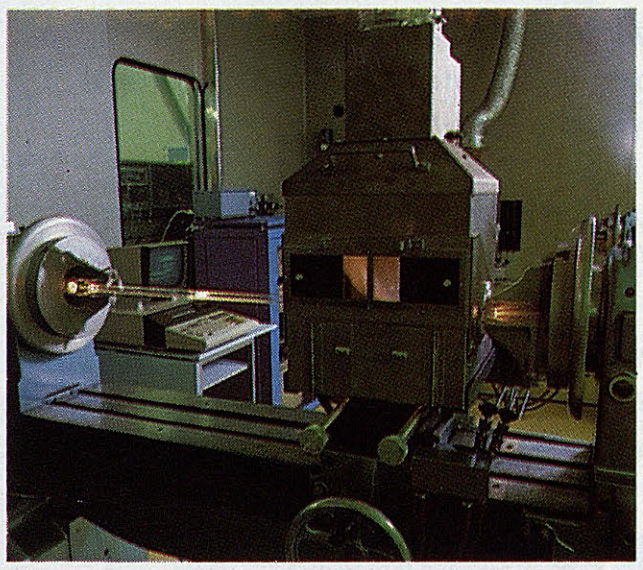
Today, subscribers are benefiting from the elimination of crosstalk and electrical interference. Business users are moving towards integrated voice and data networks. Administrations are benefiting from lower costs, easier cable installation and system maintenance.

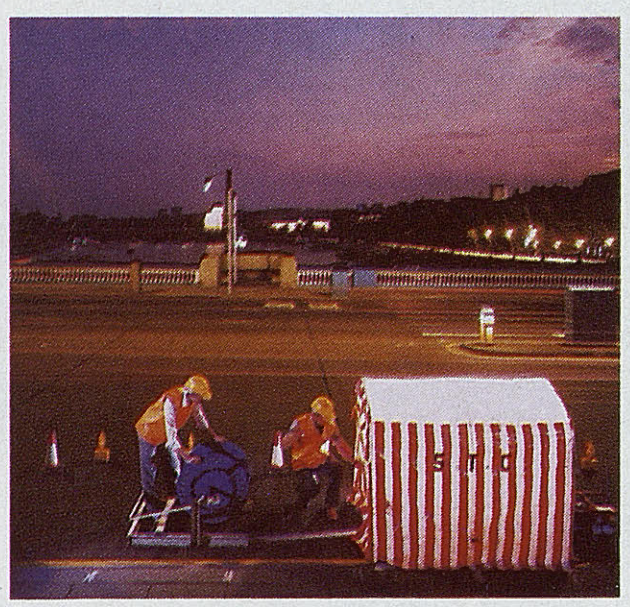
STC – the clear choice

Optical systems will play a major role in future transmission networks and British Telecom, recognising the value of optical communications, has placed major orders for optical fibre systems for the UK telecommunications network. So far 52 STC systems are planned for 19 routes throughout the UK, using 5000 km of optical fibre. STC will also be supplying Britain's first commercial monomode cable link. For the 27 km route no intermediate regenerators will be required.

Systems Capability

In 1966, two STC scientists conceived the principle of optical

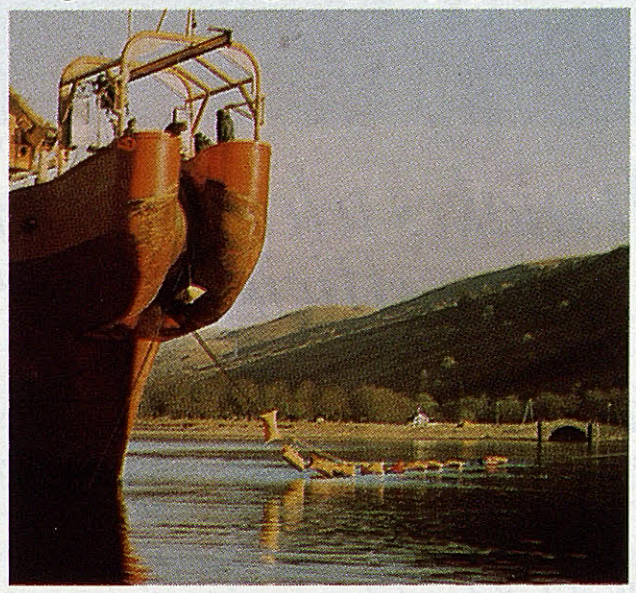




communication, and since then STC has directed its considerable resources to developing a comprehensive capability in this new technology. For a wide range of applications, STC manufactures optical fibres, and cables, optical sources, detectors, connectors, line terminals and regenerators, and optical test sets. STC also offers turnkey project management, including systems planning, installation, test and commissioning services and customer engineer training.

Landline and Submarine Systems

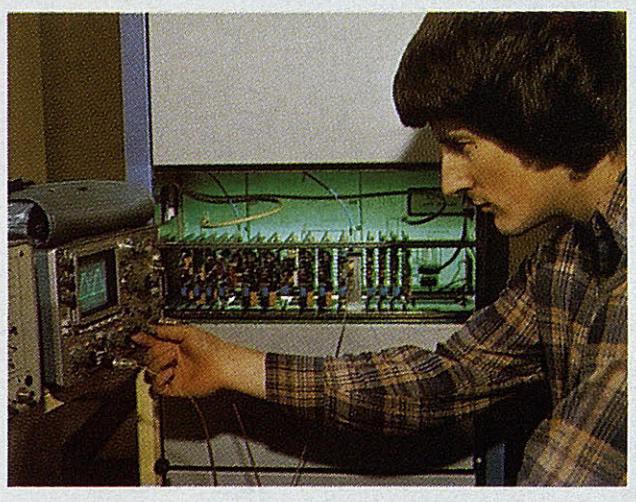
STC supplies complete optical landline systems for the trunk and junction areas compatible with established CCITT digital transmission hierachy currently used in the world's communication networks. These range from local low bit rate systems to long distance high capacity systems.



STC is currently developing high capacity systems for submarine applications, and has already laid a trial optical system in deep water off the North West Coast of Scotland. A six-fibre cable was laid and tests have shown that the tube containing the fibres can withstand pressures of 100,000 kilonewtons.

Planning for the future

Optical fibre technology is advancing so rapidly that many new applications will soon be possible. STC, using its major research and development facilities, is conducting advanced research into a number of areas including longwavelength systems, analogue systems, direct transducers, integrated optics and wavelength multiplexing.



STC are planning for future demand by updating traditional products and developing new ones which will serve the customer and industry better.

For more detailed information on how STC's telecommunications systems can help you improve network and subscriber service, complete the coupon or attach it to your letterhead.

To: STC, Dept 810,
190 Strand, London WC2R 1DU,
England. Telex: 22385

Please send more information about STC's leadership in optical communications systems.

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Company _____

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TJ2/82

STC. We help people communicate.

StarSet.® It makes telecommunications... and business...more efficient.

*And we can prove it.**

In today's business climate, maximum efficiency is vital. The StarSet ultra-lightweight headset from Plantronics can increase business efficiency up to 43 percent quickly and easily—wherever the telephone plays a substantial role in business.

Hands-free communication, increased mobility

With both hands free, work continues smoothly and with unmatched freedom. StarSet's Quick-Disconnect automatically holds calls on-line when you leave the phone temporarily. And the ultra-light StarSet delivers clear conversation—comfortably and conveniently.

Proven dependability

Because StarSet is made by Plantronics, known worldwide as "the headset company," you can depend on StarSet quality—quality that's made Plantronics headsets the communications choice for every manned American space mission from Mercury through the Space Shuttle.

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Sold by major distributors of quality telecommunications equipment, StarSet is available for quick delivery—anywhere. And service is always nearby.

StarSet makes increased efficiency easy, economical and comfortable.

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Telex: 875767 (PSAZ-CH). Telephone: (01) 784-66-88.

*Independent research conducted by H.B. Maynard and Company, Inc.

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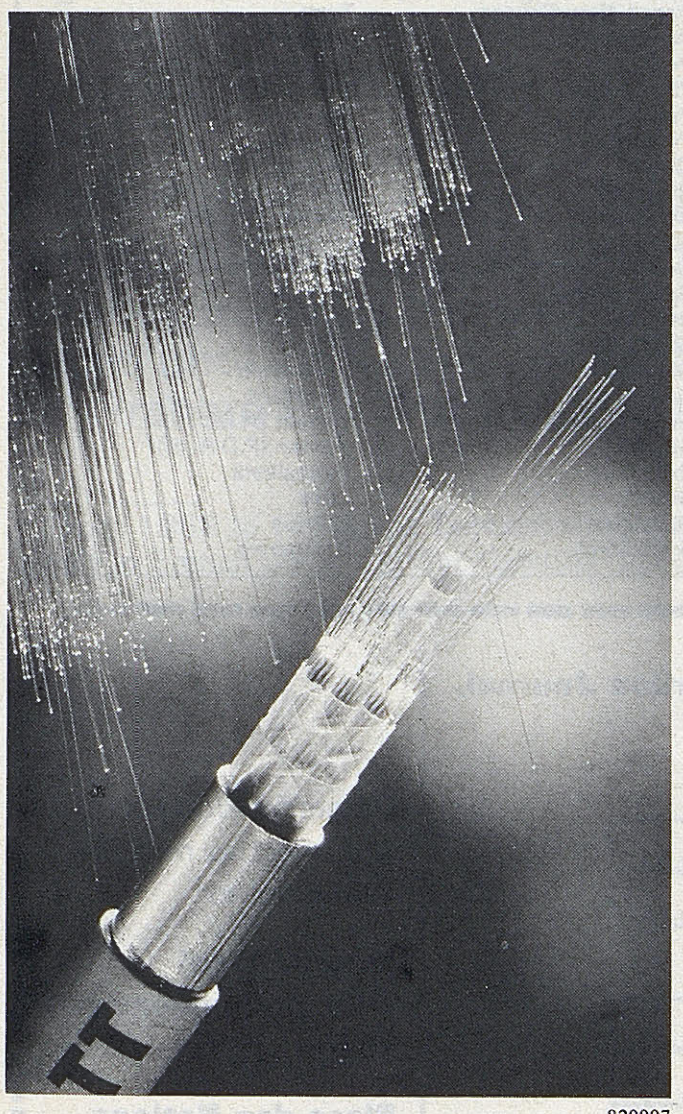

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Cover:

70-fibre optical cable, designed and manufactured by LTT, a Thomson-CSF subsidiary (LTT)

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From the idea ... to the achievement ...

Over 100 years ago, the *Journal télégraphique** published an article on Alexander Graham Bell's photophone. It is interesting to note from the extracts from that article reproduced in this issue (see page 73) that, besides the idea of a telephone working with light as the transmitting medium, the author also referred to the possibility of the electrical transmission of images "to do for vision what the telephone has done for sound".

Although Bell was able to demonstrate a working model of his photophone, it is only some 100 years later that the idea of communication by light waves has really come to practical fruition.

It is a similar story with television in that the first experimental systems came into operation in the late 1930s but were not generally introduced until the 1950s, more than 70 years after Graham Bell first expounded the principle.

Yet another brilliant idea which had to wait many years for its practical application was pulse code modulation (PCM). Although the principle was put forward in 1938 by Alec H. Reeves, it was only the invention of the transistor, followed by the development of integrated circuits, that enabled PCM to become a practical achievement.

However brilliant, any new idea has always had to undergo a long process of development before a practical technique could be devised to make it available to the public.

This second special issue devoted to the practical application of optical fibres in the telecommunication network thus marks the realization of an idea 100 years old.

In line with the policy followed since its inception 112 years ago, the *Telecommunication Journal* will continue to serve as a forum for the exposition of new ideas and to describing how they are put into practice.

M. MILI

* From 1868 to 1932, the *Telecommunication Journal* was published solely in French under the title "Journal télégraphique".

Union Activities

Twenty-five countries sign Regional Agreement for the medium frequency broadcasting service in Region 2

The Regional Administrative MF Broadcasting Conference (Region 2—the Americas) concluded its work on 19 December with the signing of an Agreement by the representatives of 25 countries. The Agreement is subject to approval by the competent authorities of those countries. It is open to accession by all other countries in the Region, which comprises countries of North and Central America and Latin America and the Caribbean areas.

A full report of the Conference will be published in a forthcoming number of the *Telecommunication Journal.*

The Conference was convened in two formal sessions:

First Session at Buenos Aires (March 1980), to prepare the technical criteria used for the planning of the medium wave band concerned (535-1605 kHz) of the radio frequency spectrum and to establish the related technical parameters (see *Telecommunication Journal,* Vol. **47,** No. *VII*, pages 434-435, July 1980).

Second Session at Rio de Janeiro (9 November—19 December 1981) to establish an Agreement, Frequency Assignment Plan and the associated provisions for the future planning and operation of the medium wave broadcasting stations throughout the whole of the Region.

The Conference was chaired by Mr. Romulo Furtado, Secretary General of Communications at the Ministry of Communications, Brazil.

Speaking at the closing ceremony, Mr. Furtado emphasized the importance of the results of the Conference as a hallmark in the history of medium frequency broadcasting throughout the Region. For the first time, he said, there was an internationally agreed legal basis for the planning and operation of medium wave broadcasting services in the Region. Procedural provisions have also been adopted to enable the future development of services, consistent with individual countries' needs.

The Agreement and Plan are to be reviewed, no later than 1988, at a regional administrative conference when the planning of services in the band 1605-1705 kHz is to proceed. This additional band was allocated for broadcasting on a phased basis by the World Administrative Radio Conference in 1979.

Between the First and Second Sessions studies were carried out by the IFRB with the assistance of a Panel of Experts established by the First Session on the service requirements submitted by all countries.

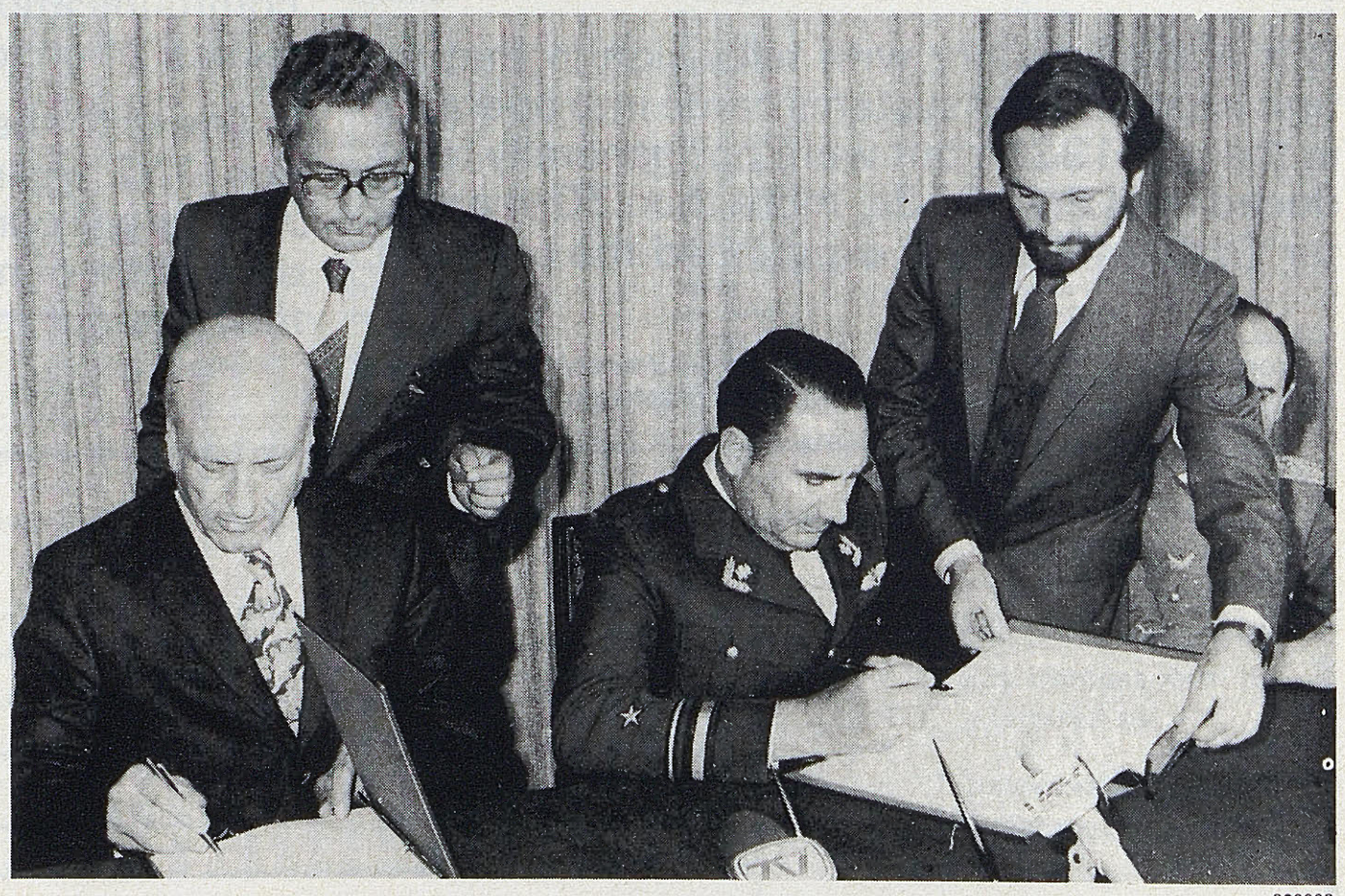
In addition, the IFRB was responsible for the development and adaptation of computer programs to serve the Conference needs, which included direct access to the ITU computer facilities in Geneva, as well as substantial computer support by the *Empresa Brasileira de Telecomunicações SA* (EMBRATEL) and various mini-computers at the Conference.

Twenty-six countries took part in the Conference, the Cuban Delegation on instructions from its Government withdrawing during the early part of the sixth week. The Plan includes the requirements submitted by all countries of the Region, including 12 which did not participate in the Conference. They have been encouraged to observe the Plan and associated provisions, and it is expected that future bilateral discussions will be initiated during 1982 on any incompatibilities.

Visit of the Secretary-General of ITU to Chile

In response to an official government invitation, Mr. M. Mili, Secretary-General of ITU, visited Chile from 4 to 7 November 1981 and entered into discussions with several governmental authorities. During the visit the Minister of Transport and Telecommunications, Air Force General Caupolicán Boisset Mújica, and Mr. Mili signed an administrative arrangement concerning a technical co-operation programme to be carried out by the ITU.

This programme covers, in particular, activities such as radio frequency management, the maritime mobile service, network planning, expansion of the telephone service in rural areas, satellite communications and training.



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The signing of the technical co-operation agreement between the ITU and the Government of Chile: (left) Mr. M. Mili, Secretary-General of ITU, (right) Air Force General Caupolicán Boisset Mújica, Minister of Transport and Telecommunications. Standing behind Mr. Mili is Mr. P. Bronzini, Head of the Americas Division, ITU's Technical Co-operation Department

CCITT News

Meeting of Joint Study Group CMBD

CCITT/CCIR Joint Study Group CMBD (Circuit noise and availability) held its first meeting of the study period 1981-1984 in Geneva from 25 to 27 May 1981 under the chairmanship of Mr. A. P. Bolle (Netherlands), assisted by Mr. N. Ohyama (Japan) as Vice-Chairman.

1. Introduction

As usual the work of CMBD was distributed between two permanent Working Parties, created during the previous study period. Working Party A is concerned with Questions on circuit noise (Questions 1, 3, 4, 5, 7, 11 and 12/CMBD). Mr. F. J. Hofman (Netherlands) was designated as Chairman of this Working Party in replacement of Mr. C. Bakker (Netherlands). Working Party B, dedicated to availability and reliability Questions (Questions 2, 6, 8, 9 and 10/CMBD) was chaired by Mr. Ohyama as in the past.

2. General remarks

The VIIth Plenary Assembly of the CCITT did not agree with the proposal that CMBD should study new questions concerning hypothetical reference circuits for digital systems with appropriate requirements regarding bit error rates (BER), etc. CMBD has to confine itself to analogue systems only. Whereas most, if not all, administrations are changing over to digital systems, new developments in the analogue field have almost completely stopped. As a consequence, the interest of administrations in analogue techniques is greatly reduced and this has, of course, its influence on the work of CMBD. CMBD considered that this study period could well be the last one for at least the noise questions. Nevertheless, Working Party A should terminate its work properly.

3. Working Party A

No contributions were received for Questions 1 and 3/CMBD (Measurements on actual loading and Measurements of usable power margin of wideband amplifiers and transmission systems). As regards Question 4/CMBD (Mathematical models for load calculations including non-speech signals) it was evident that all the mathematical models presented in the past lead to almost identical results and are in conformity with measurements carried out in practical systems. It seemed to be impossible to recommend a single mathematical model for the moment.

For Question 5/CMBD (Control of actual loading of FDM systems including non-speech signals) an interesting contribution was received about the percentage of channels with non-speech loading on INTELSAT carriers. From these figures it could be derived that it is of paramount importance to keep the level of the non-speech signals within the limits given for speech signals. Study Groups dealing with non-speech signals (data signals, etc.) should take careful account of this fact. In the framework of Question 7/CMDB (Hypothetical reference circuits and associated noise objectives) considerable progress has been made regarding an HRC of 5000 km. In addition, a proposal has been discussed on an HRC of 12 500 km and remains for further study.

As to Question 11/CMBD (Improvement of recommendations on noise measurements) frequencies of measuring channels for the now recommended 18 MHz system have been adopted. Regarding Question 12/CMBD (Consequences of the modification of the four noise clauses in Recommendation G.222) it should be remarked that the Plenary Assembly did not accept CMBD's proposal for the modification of the clauses. The modification was a deletion of the mean psophometric noise power over one hour and replacing the clause by an additional one-minute mean power clause. Therefore a rather peculiar situation has arisen because CCIR had already accepted the new clauses as a result of CMBD's firm intention to do likewise. After a long discussion, CMBD decided to start the accelerated procedure to clarify the situation before the next Plenary Assembly of CCIR. The CCITT Secretariat has sent a circular letter to administrations on the subject of the replacement of the four existing noise clauses of Recommendation G.222 by four new ones.

4. Working Party B

The reports of the reliability rapporteurs of the various Study Groups were discussed. From these reports it became clear that some Study Groups are already considering specific values for reliability and availability requirements, albeit not consistently. From this it became clear that CMBD should make haste in giving satisfactory guidance to the other Study Groups not only in defining the concepts and terms as to reliability, availability, grade of service, interruptions, etc., but also indicating general overall requirements for these concepts, for instance by means of hypothetical reference circuits.

The new Questions 2, 6, 8, 9 and 10/CMBD (General studies concerning availability and reliability; Availability and reliability of local networks; Availability of telecommunication services; Reliability of telecommunication services, once established; Allocation of the availability and reliability objectives) form an excellent basis for doing this work in addition to the already accepted Recommendation G.106. General discussions have taken place about the way the work shall be carried out during the present study period. The result of these discussions was very promising as to the expected results of the study of the Questions.

A. P. B.

* * *

Meeting of the TEUREM Group

The Tariff Group for Europe and the Mediterranean Basin (TEUREM) met at ITU headquarters in Geneva from 14 to 18 September 1981 under the chairmanship of Mr. W. Jost (Switzerland), assisted by Mr. S. Gruszczynski (Poland), Vice-Chairman.

1. Situation regarding the application of regional Recommendations

During the study period 1977-1980, TEUREM had made a number of changes to the regional Recommendations within its competence (Recommendations D.300 R - D.310 R), the most important concerning an increase in the accounting rate quota for national extensions in the telephone and telex services. TEUREM noted that the application of those changes had not given rise to any particular difficulty.

2. Study programme

2.1 On the occasion of previous cost studies, TEUREM had agreed that owing to the high additional administrative cost incurred by administrations in preparing replies to questionnaires for the collection of basic data, such studies would only be carried out every other study period. Since the last study dated back to

the period 1973-1976, TEUREM decided to undertake a new cost study during the period 1981-1984 for relations between countries of Europe and the Mediterranean Basin concerning:

— the telephone service (international part),

— the telex service (international part),

— the part of the national networks used for the above services (national extension),

— the public telegraph service,

— sound programme transmissions,

— television transmissions.

2.2 TEUREM also considered whether the studies referred to should not be extended to cover certain special facilities and new services. The tariff rates for special facilities (such as the extension of submarine cables and satellite links on the European continent) will be considered in connection with the general studies. As regards the new services, TEUREM concluded that for some a cost study would be premature (videotex, teletex), while for others the tariffs should be based on the cost factors of the supporting network (facsimile).

2.3 TEUREM also decided to undertake a cost study of telephone-type circuits and television transmissions via earth stations operating in the INTELSAT system.

3. Compilation of questionnaires for the collection of basic cost study data

3.1 In order to collect the basic data required for its cost studies, TEUREM has prepared five questionnaires, which administrations will be asked to complete. The data collected will be used as a basis for the studies in question.

3.2 In the preparation of these questionnaires, TEUREM found it necessary to:

a) fix a *reference year* for the determination of basic data in order to ensure that the data supplied by administrations should all relate to the same year and therefore be comparable;

b) fix a *target year* to calculate the future worth of the costs selected, administrations being invited to indicate the estimated annual variation of costs in their country, expressed as a percentage;

c) ask each administration to indicate the rate used for the conversion of national currency amounts into gold francs.

3.3 The data to be provided in reply to the questionnaires should relate to 1980, which has been taken as a reference year.

3.4 The new tariff rates adopted following the cost studies to be undertaken will be brought into force on 1 January 1985 at the earliest. TEUREM has accordingly chosen 1985 (end of year) as target year; for the calculation of the future worth, an average coefficient of variation will therefore have to be applied over a period of five years.

3.5 The figures to be provided in reply to the questionnaires should be expressed in gold francs. To permit verification of the extent to which the figures are indeed comparable, or, in case of doubt, to allow the reasons for any distortions to be ascertained, administrations have been invited to indicate the rate used for the conversion into gold francs of the amounts calculated in the national currency and to state at what date this rate was actually in force.

4. Deadline for replies to the questionnaires and date of the next meeting of TEUREM

The questionnaires prepared by TEUREM are to be circulated to all administrations and recognized private operating agencies in the Region during November 1981. The deadline for sending the replies to the CCITT Secretariat is 1 August 1982, and the next meeting of TEUREM is to be held from 8 to 19 November 1982.

W. J./Y. B.

CCIR

Final meeting of Study Group 10

Study Group 10 (Broadcasting service (sound)) met at Geneva from 21 September to 8 October 1981 under the chairmanship of Mr. C. Terzani (Italy).

The meeting was attended by 217 delegates from the postal administrations of 37 countries, 14 recognized private operating agencies, 5 international organizations and 2 scientific or industrial organizations.

Organization of work

The work of the various groups set up by Study Group 10 was co-ordinated by the two Vice-Chairmen, Mr. H. Eden (Federal Republic of Germany) dealing in particular with radio frequency matters and Mr. O. P. Khushu (India) with audio-frequency problems and broadcasting satellites.

It was decided to rearrange the sections in CCIR Volume X to bring them into line with the Study Group's working structure.

Study Group 10 set up the following Working Groups:

- **Working Group 10-A:** Amplitude-modulation sound broadcasting (Chairman: Mr. S. Lacharnay (France))
- **Working Group 10-B:** Frequency-modulation sound broadcasting (Chairman: Professor J. J. Geluk (Netherlands); Vice-Chairman Mr. A. Keller (France))
- **Working Group 10-C:** Audio-frequency characteristics of sound broadcasting systems (Chairman: Mr. G. Steinke (German Democratic Republic))
- **Working Group 10-D:** Revision of Questions, Study Programmes, Decisions and Terminology (Chairman: Mr. V. Quintas (Spain)).

Study Group 10 also established the following Joint Working Parties in conjunction with Study Group 11 (Broadcasting service (television)):

- **Joint Working Group 10-11R:** Recording of sound and television broadcasting programmes (Chairman: Mr. P. Zaccarian (North American National Broadcasters Association—NANBA))
- **Joint Working Group 10-11B:** Broadcasting-satellite service (Chairman: Mr. C. A. Siocos (Canada)).

The interim working parties of Study Groups 10 and 11 also met during the final meetings of the Study Groups.

Results obtained by Working Group 10-A

Working Group 10-A examined 30 contributions. The results are outlined below.

The texts concerning the protection ratios were updated, including particularly those in the HF band; amendments were made to the Report on the necessary bandwidth in amplitude modulation; a new Recommendation on HF channel separation was drafted.

The Report concerning the factors influencing coverage in the MF band was converted into a Recommendation. In the light of recent studies carried out in Hungary, changes were made to texts concerning specific field strengths and the addition of field strengths. The Report on the characteristics of broadcasting systems and the Recommendation on synchronization were amplified by additional

sections concerning HF broadcasting and in particular SSB emissions. A new Resolution was issued on the presentation of antenna diagrams to be published in the new edition of the CCIR Antenna diagrams book, and amendments were made to the report on HF antennae concerning the use of directional and non-directional antennae and the reduction of secondary lobes. A new Report was drafted on protection against lightning. This document will be transmitted to Study Group 1 (Spectrum utilization and monitoring), which will prepare a CCIR Recommendation on the subject in the light of the contributions received from the various Study Groups concerned.

Additional values of average receiver characteristics were included in the Report on this subject.

No major change was made to the texts on sound broadcasting in the tropical zone.

Results obtained by Working Group 10-B

Working Group 10-B examined 36 contributions, modifying the texts on frequency-modulation sound broadcasting as indicated below.

New Reports were drafted on theoretical network planning, the constraints affecting the planning for broadcasting in band 8, the calculation of multiple interference, involving sum-of-squares and simplified multiplication methods, and protection ratios between frequency-modulation sound broadcasting and *D/SECAM* television signals.

Amendments were made to the Reports dealing with the determination of protection ratios, the polarization of emissions (adding definitions of the types of polarization used in broadcasting), and the advantages of using orthogonal polarization. The texts on planning standards for frequency-modulation broadcasting, transmission standards and stereophonic broadcasting were also amended by the inclusion of amplitude-modulation and compandor systems.

Further, changes were made in the Reports on the transmission of several programmes or other signals in sound and television broadcasting and a new Recommendation was drafted on receiving-antenna directivity in VHF sound broadcasting, which is additional to the Recommendation concerning television antennae in Volume XI.

With a view to the future development of new sound broadcasting services, an Opinion was drafted requesting the International Electrotechnical Commission (IEC) to study the standardization of interconnection devices between sound broadcasting receivers and associated equipments for the utilization of the signals by these new services.

Results obtained by Working Group 10-C

Working Group 10-C examined 14 contributions and produced the texts described below.

A new version was prepared for the Recommendation on audio-frequency noise measurement with a view to making the measuring method more precise, and the Report on the acoustic properties of control rooms and high quality listening rooms was amplified by information on small control rooms which do not present optimum characteristics.

As regards digital techniques, two new Reports were drafted on performance measurement in studios and on the 48 kHz sampling frequency for digital sound in broadcasting studios and for television sound, including the recording of sound on sound and video tape recorders.

Study Group 10 hopes that this last Report can be converted into a Recommendation during the next study period.

Results obtained by Working Group 10-D

Working Group 10-D examined 8 contributions, with the following results:

The Recommendation on the definition of specific field strength and of the coverage area and also a number of Questions and Study Programmes were amended.

A new Question was drafted on standards for the transmission of several sound channels in one television channel and four new Study Programmes were prepared on compatibility between MF broadcasting and other services, the transmission of additional information in amplitude modulation, the use of compandors in frequency-modulation sound broadcasting and the minimum useful field strength in the VHF band. Questions 59 and 60 became Study Programmes. They had been approved by correspondence and deal with compatibility between VHF sound broadcasting, television and other services and with the technical bases for the planning of VHF sound broadcasting. A new Question was also adopted on synchronization methods in recording systems. As for satellite broadcasting, the texts and the numbering of Questions and Study Programmes in Study Groups 10 and 11 were aligned and a new Study Programme was adopted on telecommand, tracking and telemetry signals and maintenance signals.

Results obtained by Joint Working Group 10-11R

This Joint Working Group examined 15 contributions with the following results for sound broadcasting:

The Recommendation on the standards for sound recording on magnetic tape was amended and a new Report was drafted on the digital recording of audio signals, describing an experimental tape recorder prototype. The Group also proposed a list of texts for submission to the IEC and submitted a draft booklet to Study Groups 10 and 11 on recording techniques for the developing countries.

Results obtained by Joint Working Group 10-11S

This Joint Working Group examined 78 contributions, a clear indication of the great interest taken by administrations in broadcasting satellites.

Four sub-groups were set up to study the technical considerations for systems, sharing with other services, terminology, planning of services and feeder links. As a result, 13 existing Reports were updated, and a new Recommendation and five new Reports were drafted.

This new Recommendation, which concerns test conditions and measuring methods for the determination of protection ratios, brings the work of Interim Working Party 11/2 to a close.

The new Reports on sound broadcasting deal with sound broadcasting by satellite for portable and mobile receivers, multiplexing methods for the transmission of several digital sound and data signals, digital coding for the transmission of high quality sound signals and the technical characteristics of feeder links to broadcasting satellites. This last Report deals comprehensively with the various aspects of feeder links in great detail, although certain aspects of feeder links still call for further study.

Group 10-11S also prepared a list of tests which may be of interest to Interim Working Party PLEN/3 for transmission to that Working Party.

Interim Working Parties (IWPs)

IWP 10/4 (Chairman: Mr. J. Burgstaller (Austria)) was established by Decision 38 at the interim meeting of Study Group 10 to prepare the technical bases for the Planning Conference for VHF sound broadcasting in Region 1 and certain countries of Region 3. It met at Geneva in March 1981 and also during the final meeting of Study Group 10.

Twenty-one administrations, 9 recognized private operating agencies and 1 international organization were involved.

The Working Party drafted a Report based on the Conference agenda in ITU Administrative Council Resolution No. 852 which comprises six chapters concerning definitions, broadcasting and planning standards, VHF propagation, basic planning elements, frequency sharing with television and compatibility with the other services. The Report was unanimously approved by Study Group 10 and will be transmitted to the first session of the VHF Broadcasting Conference.

IWP 10/4, having completed its work, was disbanded and Decision 38 was cancelled.

IWP 10/5 (Chairman: Professor Geluk) was set up in pursuance of Decision 39 at the interim meeting of Study Group 10 to prepare the technical bases required for the planning of the HF bands allocated to broadcasting.

The Working Party met at Geneva in July 1981 and again during the final meeting of Study Group 10, preparing a report which contains the characteristics of HF DSB and SSB broadcasting systems and the data required for HF broadcasting. Two annexes deal with reliability calculations and a planning procedure for HF radio systems. Study Group 10 took note of this Report and amended Decision 39 to allow IWP 10/5 to continue its work until four months before the Study Group's next meeting, to which the final report will be submitted.

The XVth Plenary Assembly of the CCIR will take decisions on the Report of IWP 10/5 and the next meeting of Study Group 10, having regard to the fact that the ITU Administrative Council has set a new date, January 1984, for the first session of the Conference for the planning of the HF bands allocated to broadcasting.

IWP 10/6 (Chairman: Mr. N. Gilchrist (United Kingdom)) was established by Decision 40 at the interim meeting of Study Group 10 to study the parameters and tolerance limits for the technical quality of programmes intended for international exchange. It held its first meeting during the final meeting of Study Group 10 and prepared a Report and a questionnaire in order to obtain, by correspondence, the additional information needed to prepare a new Recommendation during the next study period.

By Decision 52, Study Group 10 established IWP 10/7 (Chairman: Mr. M. Schneider (Switzerland)) to identify and define the characteristics of sound broadcasting receivers necessary for planning and to prepare performance specifications for amplitude-modulation and frequency-modulation reference receivers.

IWP 10-11/1 was set up by Decision 43 at the interim meeting of Study Groups 10 and 11 under the chairmanship of Mr. J.-F. Arnaud (France) to study the utilization of the geostationary orbit and planning of the space services using it in preparation for the work of WARC-85 concerning Study Groups 10 and 11. It held a meeting at Geneva in May 1981 and met a second time during the final meetings of the two Study Groups.

Study Groups 10 and 11 took note of the Report of IWP 10-11/1 which contains three chapters dealing with feeder links, frequency planning and sharing with other services and decided that the Working Party should continue its work in order to complete and update the Report for submission to the next interim meetings, to be held in 1983/1984. Decision 43 was amended accordingly.

IWP 10-11/2 (Chairman: Mr. Siocos) was established by Decision 44 at the interim meetings of Study Groups 10 and 11 to study the techical questions relating to the Conference for the planning of satellite broadcasting in Region 2. It met in Ottawa in April-May 1981 and again during the final meetings of Study Groups 10 and 11. These Study Groups took note of the Report of IWP 10-11/2, which deals with terminology, propagation factors, the technology of broadcasting-satellite systems, planning elements, frequency planning and sharing, and decided that the report should be completed before the end of the current year.

Study Groups 10 and 11, considering that this Report should be integrated with the results obtained by the other Study Groups concerned, proposed that the XVth Plenary Assembly should adopt a Resolution convening a special joint meeting of Study Groups 4 (Fixed service using communication satellites), 5 (Propagation in non-ionized media), 9 (Fixed service using radio-relay systems), 10 and 11 to be held possibly in July 1982 to prepare the CCIR Report for the Regional Administrative Conference for the planning of satellite broadcasting in Region 2.

By Decision 51, Study Groups 10 and 11 set up IWP 10-11/3 (Chairman: Mr. O. Mäkitalo (Sweden)) to study unified standards for the insertion of several sound channels in a terrestrial or satellite television channel.

Collaboration with other Study Groups

Study Groups 10 and 11 transmitted 19 documents to IWP PLEN/3 concerning the activities of that Working Party.

Study Groups 10 and 11 transmitted to Study Group 4 the section of the Report on feeder links for broadcasting satellites concerning frequency sharing which comes within the competence of Study Group 4.

Study Groups 10 and 11 took note of the report of Mr. Arnaud, Rapporteur in Study Group 4 and IWP 4/1 and confirmed him in that office.

As agreed at the meeting of the Chairmen and Vice-Chairmen of CCIR Study Groups, the Chairmen of Study Groups 4, 10 and 11 will meet before the XVth Plenary Assembly to co-ordinate the texts concerning feeder-links for broadcasting satellites.

Study Group 10 transmitted to IWP 10/4 a Study Group 5 document proposing amendments to chapter 3 of the Working Party's report. Study Group 10 also took note of the report by Professor S. Borodich (USSR), Rapporteur in IWP 5/5, and the Working Party's final report on the division of the world into regions with a view to the allocation of frequency bands.

Study Group 6 (Propagation in ionized media) informed Study Group 10 that the main sections of Report 305-4 on propagation in the tropical zone had been transferred to Report 266-4 and that Report 305-4, which had been transferred from Study Group 10 to Study Group 6, had been cancelled. A reference to Report 266-4 will be inserted in Volume X.

Mr. H. K. Rao (India), Rapporteur in IWP 6/12, was unable to attend the final meeting of Study Group 10 which, however, received the Report of IWP 6/12 that had been transmitted to IWP 10/5.

Study Group 10 took note of the report by Mr. L. A. Witham (United Kingdom), Rapporteur in Study Group 8, and more particularly of the need to define criteria for compatibility between VHF sound broadcasting and the aeronautical radionavigation service in the adjacent upper band.

Study Group 10 took note of the verbal report by Mr. F. Angeli (Italy), Rapporteur in IWP 11/3, and appointed Mr. V. Del Duce (Italy) expert in IWP 11/5 on protection ratios in colour television.

Co-operation between Study Group 10 and CCIR/CCITT Joint Study Group CMTT (Television and sound transmis-

sion) on digital techniques is continuing by contact between the Chairmen of IWP CMTT/1 and Working Group 10-C.

Subjects of interest to the developing countries

Sound broadcasting being the most suitable information and instruction medium in the developing countries, all Study Group 10 texts are of interest to these countries. This is particularly true of the texts on broadcasting in the tropical zone, in which many developing countries are situated.

As for the recording of broadcasting programmes, Study Groups 10 and 11 are preparing a booklet for the developing countries which contains an introduction on the tasks of the CCIR, a section on the standardization of tape and film for exchange programmes and a section on the CCIR texts dealing with sound recording, videotape, film for television and the recording of television on film.

Satellite broadcasting, which can be used to set up a service for an entire population much more rapidly and at much lower cost that terrestrial networks, is a subject of ever-increasing importance for the developing countries. In particular sound broadcasting by satellite to mobile or portable receivers may be of great interest to the developing countries in the near future. The subjects of major importance for developing countries at the present time are the preparation of forthcoming ITU conferences and the results obtained by the IWPs set up for this purpose.

Study Group 10 constantly endeavours to deal with problems of concern to the developing countries. It is its hope that these countries will participate more actively in its work in future so that it can gain a better understanding of their problems and devise the most appropriate solutions.

At a meeting of the Plan Committee for Latin America in Buenos Aires on 28 October 1981, the Chairman of Study Group 10 gave a lecture on the problems peculiar to the sound and television broadcasting service in order to familiarize the developing countries with the most recent results obtained by Study Groups 10 and 11.

Conclusions

The activities of Study Group 10 during the period ending with the final meetings of September-October 1981 were marked by the study of the technical bases required for the preparation of future ITU conferences in response to WARC-79 Resolutions and Recommendations addressed to the CCIR.

Study Group 10 established the IWPs needed for these studies and approved or noted, as appropriate, the results of their work.

Intensive work continued on the rapidly developing sector of satellite broadcasting and the relevant texts were updated and supplemented by new texts.

Digital techniques are being introduced in broadcasting, including particularly programme production; other features dealt with are single sideband transmissions in HF broadcasting and the simultaneous transmission of several sound and other signals in terrestrial and satellite sound and television broadcasting.

A problem of growing importance in CCIR work is compatibility between different services using the same frequency band or adjacent bands. Study Group 10 has focused attention on this problem in relation to sound broadcasting.

Study Group 10 concludes the current study period by submitting to the XVth Plenary Assembly a series of texts which will form the basis for the future applications of sound broadcasting and for the deliberations of the conferences convened to improve spectrum utilization.

C. T.

Technical Co-operation

Propagation Seminar in the Gulf area

A Propagation Seminar under regional project RAB/78/06 "Radio Propagation Study and Proposal for a Frequency Plan" was held in Bahrain from 31 October to 5 November 1981. The Seminar was organized by Gulfvision (Riyadh) and hosted by the Government of Bahrain.

A total of 33 participants attended from the seven member countries involved in the project (Bahrain, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates) and the ITU. Five lecturers gave 16 lectures. At the opening ceremony, Mr. Saud A. Dahlawi represented Gulfvision, Mr. Khalil Al Thawadi represented the Ministry of Information of Bahrain and Mr. Ahmed Laouyane represented ITU Secretary-General Mr. M. Mili. Subjects presented and discussed included "Propagation measurements by minicomputer-controlled automatic station", "Refractivity characteristics of the Gulf area" and "Modes of propagation of television signals in the Gulf area".

One day of the Seminar was devoted to the presentation of a draft pre-plan proposal for bands IV and V for the Gulf countries. The discussions which ensued terminated with an agreement to discuss and obtain decisions on certain items at the next Gulfvision Engineering Meeting to be held in Riyadh on 29-30 November 1981.

The helicopter propagation study, undertaken at the time the Seminar was being held, aroused a great deal of interest among the participants. A lecture on the subject of the campaign was given and the delegates had the opportunity, in the presence of the Minister of Information, to see the fully-equipped helicopter and meet its crew and technical team.

The Seminar culminated in requests for further seminars of this nature.

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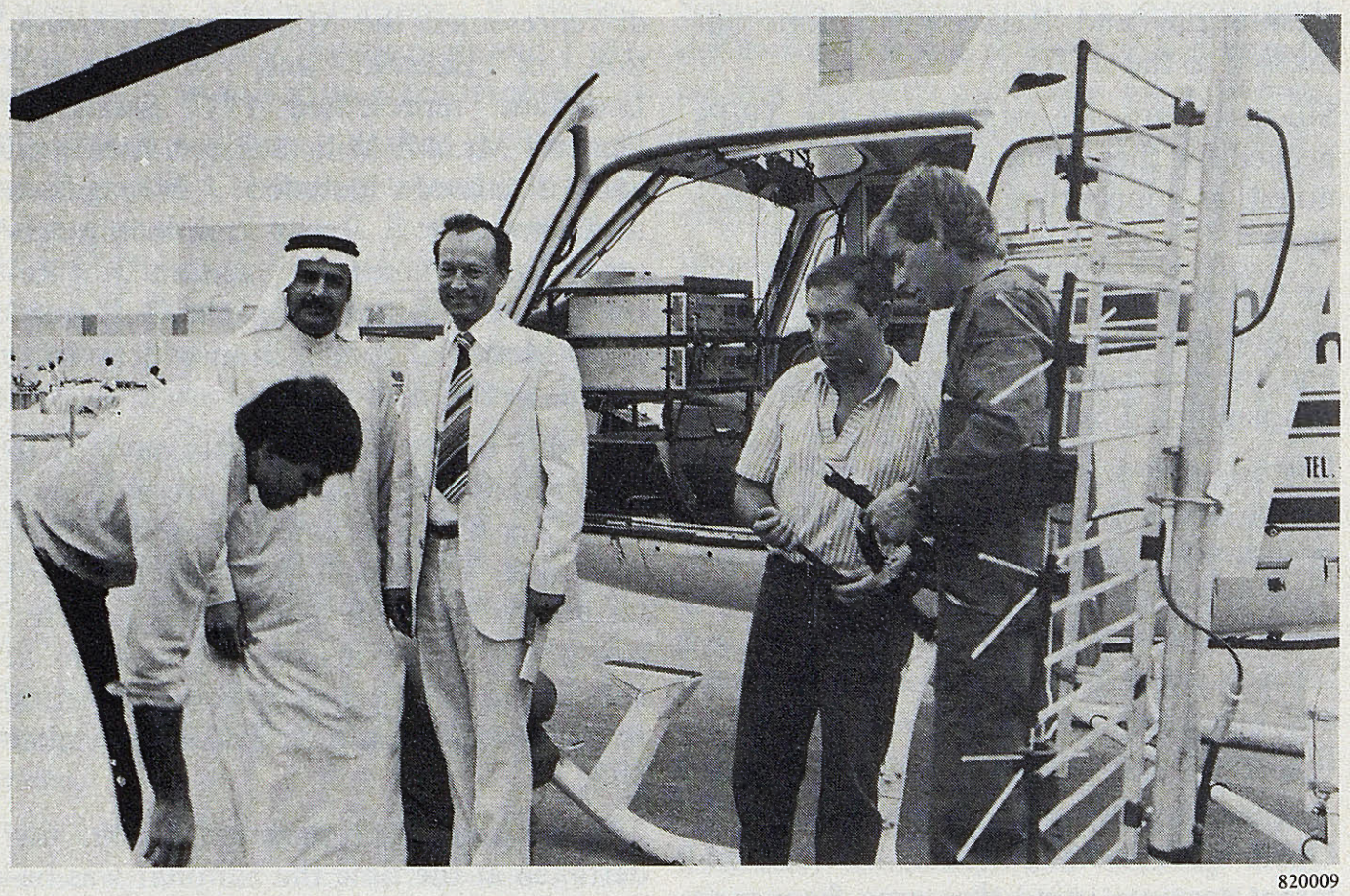
Helicopter aids propagation studies

The Governments of Bahrain, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates have applied to the ITU for assistance in undertaking detailed studies of radiowave propagation in the Gulf countries with a view to avoiding interference with and between television services in the Gulf area, such assistance being financed by the above-mentioned Governments under a Trust Fund agreement concluded between Gulfvision representing these Governments, and the ITU, on 5 May 1979.

Among the activities of the study, there is a campaign for plotting transmitting-aerial radiation patterns by means of a helicopter. Measurements of 11 UHF/VHF transmitter patterns in the Gulf were taken during the 43-day campaign period.

The helicopter measurement campaign began on 21 October 1981 in Kuwait, thus the results of the measurements taken in Kuwait were available for presentation at the Gulfvision Seminar held in Bahrain 31 October to 5 November 1981. The helicopter arrived in Bahrain



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View of the helicopter at the television station in Issa Town, Bahrain, showing the equipment in the helicopter and the receiving antenna on the right

from Kuwait and undertook measurements there before continuing its mission to Dammam (Saudi Arabia), Doha (Qatar), Abu Dhabi and Al Ain (United Arab Emirates), Buraimi and Muscat (Oman), Dubai (United Arab Emirates), from where it returned to Paris.

The *SOFRATEV/TDF* French company, based in Paris, was employed to undertake this campaign. Their team consisted of one chief engineer, two technicians, one pilot, one maintenance technician, one helicopter erector and dismantler and one ITU expert.

Two *ESU2* selective voltmeters and one Hewlett-Packard calculator were the main items of equipment used aboard the helicopter. The tracing table, which was connected to a second Hewlett-Packard calculator, automatically gave horizontal or vertical radiation patterns at the end of each measurement recording.

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Twenty-two more fellowships

Twenty-two more fellowships were arranged by the ITU Technical Co-operation Department between mid-November and mid-December 1981 for recipients from five countries.

Two fellows from Haiti are studying outside plant and engineering in the United States, two from Algeria are studying minicomputers in France and a group from Saudi Arabia are studying power systems, also in the United States. Other subjects of study include digital switching techniques, high speed data transmission, and maintenance organization.

Departures on mission

country and place of assignment	expert	assignment	period of contract and programme*
Afghanistan Kabul	Izo K. (Czechoslovakia)	Adviser on outside plant at the Telecommunication Training Centre	30.11.81-29.3.82 UNDP
Botswana Gaborone	Perera W. S. (Sri Lanka)	Senior expert in radio frequency management	22.11.81-21.4.82 UNDP
Brazil Campinas	Abi-Aad A. (Canada)	Senior expert in testing of electronic switching equipment—software at the Telecommunication Research and Development Centre	14.12.81-13.12.82 UNDP
Burma Rangoon	France E. T. (United Kingdom)	Training expert in telecommunications management at the Telecommunications and Postal Training Centre	9.11.81-8.11.82 UNDP
Djibouti Djibouti	Sidibe M. (Mali)	Team leader/training expert in radiocommunications and basic electronics	4.12.81-3.12.82 UNDP
	Chakraborty N. C. (India)	Training expert in outside plant and subscriber apparatus	6.12.81-5.12.82 UNDP
Ethiopia Addis Ababa	Henriksson P.-O. (Sweden)	Training expert in outside plant and subscriber apparatus at the Telecommunication Training Institute	2.11.81-1.11.82 UNDP
	Falk J. E. (Sweden)	Senior expert in telecommunication course development at the Telecommunication Training Institute	22.11.81-21.11.82 UNDP
	Prasad S. M. (India)	Senior expert in establishment and settlement of accounts in the international telecommunication service at the pan-African telecommunication network (PANAFTEL)	22.11.81-21.2.82 UNDP
	Pramanik A. K. (Bangladesh)	Project co-ordinator/training expert in radio-relay systems and multiplex at the Telecommunication Training Institute	28.11.81-27.11.82 UNDP
	McDonagh D. P. (Ireland)	Training expert in telephone switching at the Telecommunication Training Institute	29.11.81-28.11.82 UNDP

country and place of assignment	expert	assignment	period of contract and programme*
Greece Athens	Myrenfors G. (Sweden)	Senior expert in modern management techniques for the Middle East and Mediterranean Telecommunication Network (MEDARABTEL)	31.10.81-8.11.81 UNDP
	Urben T. (United Kingdom)	Senior expert in maintenance organization and management	29.11.81-8.12.81 UNDP
Haiti Port-au-Prince	Casalta P. (Canada)	Adviser in planning and development of telecommunication networks	7.12.81-6.12.82 UNDP
Hungary Budapest	Matthew J. D. (United Kingdom)	Senior expert in traffic engineering	4.12.81-13.12.81 UNDP
Malawi Blantyre	Wedzinga G. (Netherlands)	Associate expert in radio and transmission at the Multi-Country Posts and Telecommunications Training Institute	8.11.81-7.11.82 Associate expert
Morocco Casablanca	Nyberg N. G. (Sweden)	Senior manitenance expert	4.12.81-3.6.82 UNDP
Oman Muscat	Wild W. (Sweden)	Specialist in digital transmission	3.12.81-17.12.81 FT
Philippines Manila	Donaldson A. (Canada)	Senior adviser in telecommunication management	30.11.81-22.12.81 UNDP
	Horne F. (United Kingdom)	Senior adviser in telecommunication development planning	1.12.81-21.12.81 UNDP
Saudi Arabia Riyadh	Zaier B. (Tunisia)	Senior expert in planning of telecommunication networks	21.11.81-20.11.82 FT
	Fahmi A. R. (Sweden)	Senior expert in electronic switching systems	26.11.81-25.11.82 FT
	Brouwer J. M. (Netherlands)	Telecommunications adviser	5.12.81-4.12.82 UNDP
Thailand Bangkok	Agarwal S. M. (India)	Senior expert in restructuring telecommunication organizations	8.11.81-22.11.81 UNDP and 13.12.81-31.12.81 UNDP
Tunisia Tunis	Al Atassi A. S. (Syria)	Senior regional telecommunication adviser for the Arab States	17.10.81-31.12.82 UNDP
	Roux J. (France)	Training expert in electronic switching *E10 B* at the School of Posts andd Telecommunications	18.11.81-18.11.82 UNDP
Yemen A. R. Sanaa	Halabi A. (Syria)	Senior expert in the planning and construction of outside local network plant	13.12.81-12.3.82 FT

* UNDP = United Nations Development Programme.
FT = Funds-in-Trust.
Associate expert = Mission financed by the associate expert's national government under an agreement between that government and the ITU for the provision of associate experts.

Conferences or meetings external to the ITU

Calendar of non-ITU scientific and technical meetings

date	place	title and organizer	further information from
1982			
2-4 March	Monte Carlo	Airline Telecommunications and Data Processing Conference (SITELCOM-82) *SITA (Société internationale de télécommunications aéronautiques)*	Information and Public Relations Department, SITA 112, avenue Charles-de-Gaulle F-92522 Neuilly-sur-Seine Cedex (France) Tel.: 758 13 22 Telex: 620520 F

date	place	title and organizer	further information from
9-11 March	Zurich	1982 International Zurich Seminar on Digital Communications: "Man-machine interaction" *IEEE Switzerland Chapter on Digital Communication Systems*	Secretariat 82 IZS Miss M. Grey, EAE Siemens-Albis AG CH-8047 Zürich (Switzerland) Tel.: + 41 1 247 51 20 Telex: saz ch 52 131
29-31 March	Paris	New trends in passive components *Société des électriciens, des électroniciens et des radioélectriciens* and others	Secrétariat général du Colloque international sur les nouvelles orientations des composants passifs 11, rue Hamelin 75783 Paris Cedex 16 (France) Tel.: 33 (1) 505 14 27 Telex: Sycelec Paris 611045 F
13-17 June	Philadelphia	International Conference on Communications (ICC'82) "Communications: The digital revolution" *Institute of Electrical and Electronics Engineers*	Dr. Paul Schnitzler RCA Laboratories Princeton, NJ 08540 (United States) Tel.: (609) 734-2199
27-30 June	Paris	4th International Conference on Futures Analysis, Forecasting and Planning for Telecommunications, Energy and Public Utilities	Ecole nationale supérieure des télécommunications 46, rue Barrault F-75013 Paris (France) Tel.: 589 66 66
6-10 September	Budapest	7th Colloquium on Microwave Communication (7th MICROCOLL) *International Union of Radio Science* and the *Hungarian Academy of Sciences*	Secretariat of the 7th MICROCOLL H-1525 Budapest, 114 POB 15 (Hungary) Tel.: 150-013 Telex: 22-4338
7-10 September	London	6th International Conference on Computer Communication (ICCC 82) *International Council for Computer Communication*	ICCC 82, PO Box 23 Northwood Hills HA6 1TT Middlesex (United Kingdom) Tel.: + 44 92 74 27 511 Telex: 25-198
18-21 September	Brighton	9th International Broadcasting Convention (IBC 82) *Electronic Engineering Association, Institution of Electrical Engineers* and others	IBC Secretariat Institution of Electrical Engineers, Savoy Place London WC2R 0BL (United Kingdom)

Obituary

Roy F. Stevens, G2BVN

On 30 September 1981, aged 61, Roy Stevens, Secretary of the International Amateur Radio Union (IARU) Region 1, died after a long illness which he had borne with great courage.

With his death the world of amateur radio has lost both a friend and a leader who, over the last 25 years, was largely responsible for creating the image of amateur radio as an instrument of friendship, peace and technical education. He acquired his call sign *G2BVN* as far back as 1937. During the war he served in the radio traffic monitoring unit of the Royal Air Force, escaping from occupied France one month after the battle of Dunkirk.

For 18 years he worked as a member of the Board of the Radio Society of Great Britain and was appointed President of its Amateur Radio Council in 1966. Until his death he edited the organization's publication *Radio Communications*. As RSGB liaison with the British post and telecommunication authorities, he attended WARC-79 as a member of the United Kingdom delegation.

For 12 years he served as Secretary of IARU Region 1 division, with the special task of maintaining the liaison with ITU headquarters in Geneva. Only his closest friends and, in particular, his assistant Audrey Jefcoate, can fully understand the work he accomplished from early morning until late at night to promote international amateur radio and to prepare radio amateur contributions to international conferences. In the course of his international liaison work he often visited ITU headquarters where he made many friends. In 1974 he acquired the Swiss call sign *HB9BBX*.

He considered his last visit to Geneva on the occasion of WARC-79 as the highlight of his career as a radio amateur. In spite of his illness he participated in the three-month conference, attending meetings and discussions. Thanks to his efforts the conference allocated three additional amateur bands in the shortwave operation of the radio frequency spectrum.—*DL1YJ*.

Bell's photophone.

At the last meeting of the American Association, *Alexander Graham Bell*, the famous inventor of the first speaking telephone, recently revealed an extremely interesting piece of information. He has devised an instrument which he calls the *Photophone* because it is used to transmit sounds by means of a light beam. Whereas the conventional telephone requires metal conductors to link up two stations, the photophone receiver is quite separate from its transmitter. It is sufficient for a light beam to be able to cross the space between the two without encountering any opaque obstacle. And even this condition is not a rigorous one since certain kinds of screen do not always preclude verbal communication.

The principle on which the photophone is based has already been known for several years now. It is the scientist Willoughby Smith who can claim the honour of its discovery. On 12 February 1873 he told the London Society of Telegraph Engineers that *selenium* had a much lower resistance to electric current on exposure to light than it did in the dark. The idea of a telephone exploiting this singular phenomenon was only a small step away, and indeed the same thought occurred to several people almost simultaneously. Among others we shall mention Mr. Adriano Paiva, Professor at the Academy of Porto; Mr. Senlecq of Ardres, etc.

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The first practical applications occurred. At the same time, several people visualized arrangements to solve another most attractive problem which, it must be admitted, were rarely put into practice. This was to do the same for sight as the telephone had done for sound. To find a way *using electricity* of seeing in Paris what is happening at exactly the same moment in the antipodes! Those who had great confidence in electricity—and there were any number of them—set to work and racked their brains to find the much sought-after solution.

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Now we come to Bell's photophone.

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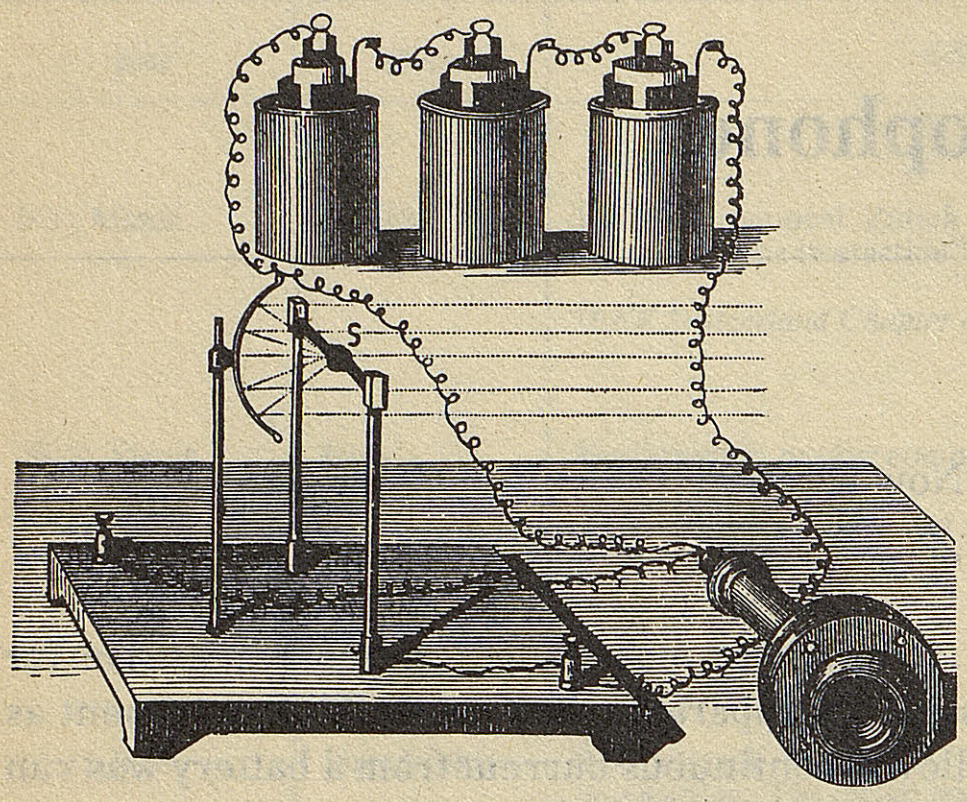
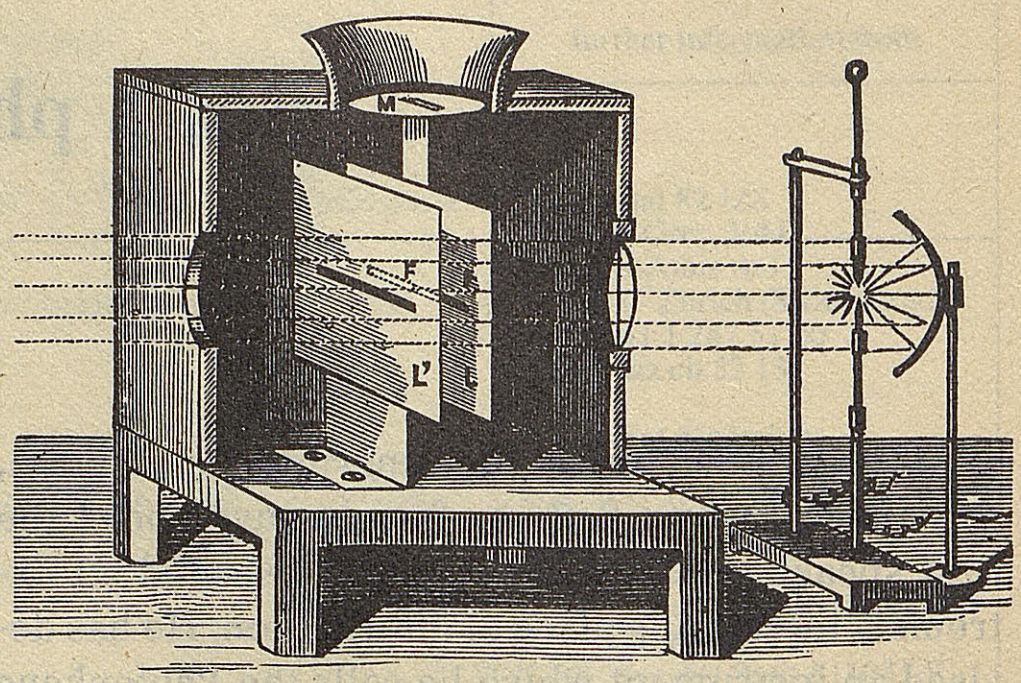
. . . In order to make selenium more sensitive for use in his apparatus, Bell set up his experiment as follows: continuous current from a battery was run through a selenium rod placed in a speaking telephone circuit. A light beam, switched on and off very frequently within the space of one second, was projected onto the selenium, i.e. a series of pulses of light in rapid succession. Each of these pulses caused a variation in the resistance of the selenium and consequently in the strength of the current running through the circuit. The telephone in the circuit was thus subject to corresponding changes in magnetization.

If 435 pulses are applied in this way, these will cause 435 variations in current and the telephone receiver plate will undergo 435 vibrations, i.e. the note *la* of the basic scale. Such apparatus could thus be used to transmit musical sounds. It remaind to be seen whether the tone of these sounds could also be transmitted or, which comes to the same thing, whether the human voice with all its subtle gradations could also be received.

To do this, Bell installed two small plates closely parallel to one another (L, L′) with two narrow slits (F, F) directly opposite one another so that a light beam could pass freely through them. One of the plates, L, was fixed to a rigid support while the other was attached at right angles to a thin telephone membrane, M. When words are uttered in front of a membrane it vibrates and moves the plate along with it. Hence at certain moments the two slits are no longer directly opposite one another and the light beam is fully or partially eclipsed. In short, the strength of the beam is constantly varying in direct proportion to the varying amplitudes of the membrane vibrations. This is what Bell called an *undulating* light beam. So much for the transmitting station.





The other station, which is a given distance away from the former, contains the receiver comprising selenium, the battery and the speaking telephone. The undulating beam is directed at the selenium and is continuously acting upon it in proportion to its strength. This results in *undulating* variations in the metalloid's resistance and corresponding vibrations in the telephone. In short, the words spoken against the membrane in the first station can be heard on this telephone.

Bell describes an experiment carried out at a distance of 213 metres. His assistant Mr. Tainter took up position on the roof of the Franklin schoolhouse in Washington, and the receiver system was placed in the window of his laboratory in 1325 L Street. He tells of having distinctly heard the following words when he put the telephone to his ear:

"Mr. Bell, if you hear what I say, come to the window and wave your hat."

In the face of such a precise account, there is no alternative but to accept the facts, however miraculous the photophone might appear.

However, to reach this stage, Bell met a number of difficulties which he had to overcome at the outset.

When he embarked on this method of research which has recently produced such magnificent results, he realized that selenium had a much higher electrical resistance than his telephones, and this constituted the first obstacle on the road to success. He had to take steps to reduce this resistance and build telephones in line with the new conditions imposed.

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To prepare selenium to make it conduct as required, it must be heated in a gas oven. Observation of its surface reveals that at a particular moment the selenium tarnishes as if through condensation and takes on a metallic, crystalline appearance. At that moment the selenium is removed from the oven and left to cool . . .

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Selenium treated in this way conducts as desired. But there is another no less important condition which has to be fulfilled. Selenium does not only have to be a good conductor, but it must also be sensitive to the shortest, most rapid effects of light; for if a significant, or to put it a better way, measurable time is needed for the light beam to modify its resistance, it would be incapable of reflecting the continuously changing gradations of the beam and at least the tone if not the note itself would be in no way transmittable.

Without any doubt the beam acts upon the surface only. The selenium must therefore be cut into shapes with a very large surface area-to-mass ratio.

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The best layout of all those tried is one in which the light beam is reflected on a flat, flexible mirror such as a silvered sheet of mica or thin glass. The speaker talks against the mirror and it is the mir-

ror's own vibrations which constantly change the direction of the reflected beam.

The light source used was the rays of the sun which were focused on the mirror through a lens and made parallel by way of another lens straight after reflection. But transmission is also possible using an electric light source and even a gas or oil lamp.

On arrival, the rays were all directed by a parabolic reflector to the same point, its focal point, where the piece of selenium to be acted upon was placed. As before, the selenium was connected to a circuit with a battery and a conventional telephone.

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But this is not the last of the surprising facts which Bell reveals. If the *vibratory* light beam is directed against a sheet of rubber, this sheet of rubber, as is easy to discern by approaching one's ear, emits a sound. A thin sheet of selenium also demonstrates the same property! And not only selenium—but also gold, silver, platinum, iron, steel, brass, copper, zinc, lead, antimony, nickel-silver, Jenkin's and Babbitt's alloys, ivory, celluloid, gutta-percha, paper, parchment, wood, mica and silvered glass!

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The photophone provides yet more proof that anything capable of inducing changes in the electrical properties of bodies can be used to construct a telephone.

These changes may act on the electromotive force, in which case no battery or external power is required, as in the case of Bell's telephone and the mercury telephone.

They may act on a substance's capacitance in which case no external energy would be required either. No telephones based on variations in capacitance in fact exist, although several physicists have attempted experiments on these lines.

They may also act on the substance's resistance. In this case an electric current, i.e. an external power source, must be introduced into the system. This is the case in the microphone, the Edison telephone and also in the photophone discussed in this article.

But if these various processes enable transmission of reproduction of the human voice, it is also thanks to the prodigious subtlety of our own hearing. No known amplification process has yet proved capable of physically demonstrating the vibratory movements of a telephone receiver membrane collecting human speech rather than a musical note. And yet these movements do exist. This only goes to prove therefore that their amplitude is incredibly small. Indeed, it is there that the secret of the telephone lies. For such small variations and such minute movements, the elasticity of metallic plates, the pressure of two substances already in contact, the electrical resistance of a conductor, sensitivity to light, etc., may be considered as being rigorously proportional to the causes which induce changes in them. In other words, the effects are totally and completely dependent on the causes.

This also explains why it is so difficult to increase the telephone's power beyond a certain limit. Beyond a certain amplitude this dependence no longer exists and the apparatus functions badly.

What might the practical applications of the photophone be?

It is always risky to make predictions, whether optimistic or pessimistic. Nevertheless, we believe that the photophone will never supersede the telephone. Naturally it is extremely convenient to be able to transmit messages without the need for costly, cumbersome and accident-prone conductors. But these conductors can follow curved paths, whereas a light beam must always travel in a straight line. To correspond using the photophone, the two stations would have to be placed in such a way that no opaque obstacle, no wall, house or mountain comes between them or interrupts the straight line linking them. Of course, metallic mirrors or other types of reflector could be used to redirect the beam if absolutely necessary; but such reflections would absorb a considerable proportion of the incident beam, reducing its power and thus its range.

And yet would it be absurd to hope that the day might come when actual photophonic relays are established? From the theoretical point of view certainly not. Who could possibly prevent the light beam from acting on a selenium receiver with a membrane which would in turn act on a light beam belonging to a further local light source, etc.? *A priori* we see no scientific objection to the functioning of these successive relays, and their construction, if

it ever proves possible, will enable contact to be established between any two points along a completely straight line without any need for them to be mutually visible.

But we have little practical experience in this connection. Bell does not speak of any, and it is only a bold hope which we are venturing to express.

Apart from public or private applications, there might indeed still be cases where this apparatus could be truly useful. Our readers will no doubt remember the geodesic experiments carried out by Colonel Perrier and General Ibanez in an effort to link Spain and Algeria by direct triangulations.

The electric lights of the Sierra Nevada and the African mountains were reciprocally visible for both stations. Could one not have used these very same lights to speak to Algeria from Spain and vice-versa using the photophone?

Journal télégraphique—October 1880

New research and discoveries in photophony.

... Their transmitter apparatus is the same as the one described for the photophone. It is a thin mirror which bends in proportion to the speaker's voice projected against it and in so doing constantly modifies the strength of a reflected light beam.

The receiver can be made of any substance, but the best results are obtained using a piece of gauze covered with lampblack stretched tight across the open end of an ear trumpet.

The experiment was totally successful for a distance of 40 metres between the receiver and transmitter, and would surely be a success for greater distances.

Here then is the photophone in its simplest form—no more battery, no selenium, no telephone, just some lampblack and a mirror!

In the course of their experiments the two physicists (Bell and Tainter) noticed that the loudest sounds are produced by divided, spongy or porous substances and by substances which are the darkest in colour or have the greatest capacity for absorption. This can be explained as follows. Let us consider, for example, lampblack, whose temperature rises when it is acted upon by radiations across the whole refrangibility range. It is a kind of sponge with its pores full of air rather than water. When the sun's rays shine on it, its particles are heated, expand and thus naturally cause the intervening cavities to contract. As a result air is expelled exactly as water is expelled when a sponge is squeezed. The force of the expansion of the air is still further increased by its own expansion through contact the heated substance.

When the light source is removed, the process is reversed. The lampblack contracts, the spaces between expand, and air is re-absorbed to balance the processes.

One could explain in this way how a substance such as lampblack produces strong vibrations in the surrounding air while only causing a very small vibration in a diaphragm or a solid over which it is stretched, and the experiment verifies this.

This is the phenomenon which W. Preece had observed when he came to the conclusion that the membranes do not vibrate and that only the air moves.

However, Bell's views do not entirely match those of the learned Post Office electrician on this point, and in support of his assertion he quotes the experiment in which a vibratory light beam is projected on to a Blake microphone membrane. A telephone connected to the microphone's secondary circuit will receive the note. Hence the membrane must have vibrated in the mechanical sense of the word.

Lord Rayleigh even established analytically that successive heating and cooling could cause vibrations of sufficient amplitude for a sound to be obtained. This amplitude may incidentally be as little as one ten-millionth of a centimetre.

Sounds produced using liquids are much more difficult to observe than those obtained using solids, even though their considerable power of absorption might suggest the opposite.

Journal télégraphique—May 1881

WORLD COMMUNICATIONS YEAR

Development of Communications Infrastructures

1983

The General Assembly,

. . . . .

Recognizing the fundamental importance of communications infrastructures as an essential element in the economic and social development of all countries,

Convinced that a World Communications Year would provide the opportunity for all countries to undertake an in-depth review and analysis of their policies on communications development and stimulate the accelerated development of communications infrastructures,

1. Endorses the proposal made by the Economic and Social Council in paragraph 1 of its resolution 1981/60 and proclaims the year 1983 World Communications Year: Development of Communications Infrastructures, with the International Telecommunication Union serving as the lead agency for the Year and having responsibility for co-ordinating the interorganizational aspects of the programmes and activities of other agencies;

2. Requests all States to participate actively in the attainment of the objectives of the World Communications Year;

. . . . .

Extract from United Nations General Assembly resolution 36/40

Eighth meeting of the Inter-agency Committee for World Communications Year

The eighth meeting of the Inter-agency Committee for World Communications Year was held on 3 December 1981 at ITU headquarters under the chairmanship of Mr. M. Mili, Secretary-General of ITU, who was appointed co-ordinator of the Year by the United Nations General Assembly. The following organizations were represented: United Nations (UN), Economic Commission for Africa (ECA), Economic Commission for Europe (ECE), United Nations Development Programme (UNDP), Food and Agriculture Organization of the United Nations (FAO), United Nations Educational, Scientific and Cultural Organization (UNESCO), World Health Organization (WHO), International Bank for Reconstruction and Development (IBRD), Universal Postal Union (UPU), International Telecommunication Union (ITU), World Meteorological Organization (WMO) and Inter-Governmental Maritime Consultative Organization (IMCO).

In his opening address, the ITU Secretary-General observed that, since the last meeting held on 10 July 1981 at ITU headquarters, the situation had evolved rapidly and had taken a favourable turn: on 19 November 1981, the United Nations General Assembly had officially proclaimed 1983 World Communications Year (WCY) in resolution A/RES/36/40 adopted by consensus. From the contacts established with the donor countries and with authorities interested in WCY, it was clear that the response was very favourable in all circles.

He also said that the activities of the Year would be conducted primarily at national level and there was widespread evidence of a firm resolve to make the World Year a period during which concrete projects could be implemented or launched, since not all the activities of the Year would come to an end in December 1983. The resolution of the United Nations General Assembly stressed the need for all countries to undertake an in-depth review and analysis of their policies on communications development. It would thus be a year for thought during which a number of projects would be launched for gradual implementation over several years.

The following items, *inter alia,* were considered at the meeting:

1. Planning of preparations for WCY
2. Programme proposed for WCY by the various agencies or bodies of the United Nations system
3. Suggested measures for the effective participation of the national committees of all sectors of activity involved in the development of communications infrastructures
4. Approval of the "Guide to WCY"
5. Approval of the presentation of the "WCY Register of Activities"
6. Review of the list of "Proposed pilot projects for WCY" (see page 79).

1. The plan of action for the preparations for WCY was adopted. It comprises the following stages for the first half of 1982:

1st quarter

- Distribution of the Guide to WCY: end January
- Letters announcing WCY to: end January
  - □ administrations
  - □ Ministries of Foreign Affairs, through the Permanent Missions
- General information action: end March
  - □ regional organizations
  - □ organizations such as the European Broadcasting Union (EBU), the Union of National Radio and Television Organizations of Africa (URTNA), etc.
  - □ scientific organizations and recognized private operating agencies
  - □ donors
  - □ universities

- □ radio
- □ press

- WCY Bulletin, issued by the WCY secretariat every three months in 1982 and every two months in 1983
  - □ WCY Bulletin (No. 1): end March
- Preparation of the report to the Economic and Social Council (ECOSOC): end March

2nd quarter

- Meeting of the Inter-agency Committee: 15 April
- WCY Bulletin (No. 2): June
- Register of Activities: June

2. The various agencies represented then outlined the programmes they are currently developing for WCY:

The competent division of ECA has planned a number of activities to promote telecommunications which it has proposed to the governing bodies of the Commission without however obtaining the necessary funds. It is hoped that other sources of financing will be found for these activities which in the Africa region relate to the pan-African telecommunication network (PANAFTEL), to satellite communications for Africa, to broadcasting for national development and to communication techniques for development. It is to be noted that the ECA will celebrate its 25th anniversary in 1983, an event which will enhance the impact of WCY in Africa.

After recalling that ITU was one of UNDP's main executing agencies, the UNDP representative expressed the hope that the interest which WCY aroused would make the developing countries more aware of the importance of telecommunications and that they would accordingly ask UNDP for greater assistance to set up communications infrastructures. UNDP has not yet defined any guidelines for its activities although it appears that the best solution would be to involve the Resident Representatives. UNDP expects ITU to make further suggestions on the way in which it might make an effective contribution to WCY.

In view of the preponderance of telecommunications in many of FAO activities, World Communications Year is expected not only to promote the setting up of communications infrastructures in the various countries but also to lead to innovations useful for agriculture.

UNESCO will contribute through activities under its regular programme and will draw up pilot projects. It also plans to make a series of information broadcasts and to issue press releases on WCY.

It is in connection with health information and education that WHO intends to stress the importance of communications development. The structure of WHO, with six regional offices and a large number of staff in the field, enables it to work in close collaboration with UNDP.

The World Bank plans to finance a number of telecommunication projects in the years 1982-1983; if WCY can induce a greater number of developing countries to take more interest in the telecommunication sector and to grant it higher priority in their investment programmes, the World Bank will certainly adopt a favourable approach to any request for funding.

The activities planned by UPU include not only those conducted at national level in order to publicize the Year but also international and regional activities and a series of pilot projects centred on specific efforts which will benefit primarily the less developed countries.

As far as WMO is concerned, the 1983 World Meteorological Day, for which responsibility has been entrusted to the World Weather Watch team, will be closely linked with WCY. WMO will also issue press releases on WCY and might also publish articles on the Year in the quarterly *WMO Bulletin.* Subject

ANNEE MONDIALE DES COMMUNICATIONS
WORLD COMMUNICATIONS YEAR
AÑO MUNDIAL DE LAS COMUNICACIONES
1983

FICHE DU "REPERTOIRE DES ACTIVITES DE L'AMC" 1983

"WCY REGISTER OF ACTIVITIES" 1983

"REPERTORIO DE ACTIVIDADES DEL AMC" 1983

1. Contrôle N° Control No. Control N.°	2. Origine Origin Origen
3. Titre Title Título	
4. Genre d'activité Type of activity Tipo de actividad	
5. Lieu/Place/Lugar	6. Date/Fecha
7. Organisation Organization Organización	
8. Contact Contact Responsable	
9. Domaines principaux/Main subject area/Temas principales	

to future decisions, the ninth session of the World Meteorological Congress to be held in May 1983 might provide an ideal forum for drawing the attention of members of governments, regional organizations and other bodies to the importance of World Communications Year.

For the 1983 World Maritime Day, IMCO might select a theme centred on maritime communications; it might publish an issue of *IMCO News* in 1983 on the contribution of maritime radiocommunications to the safety of shipping and to pollution control; it might also organize, concurrently with the 13th session of the Assembly, a special exhibition displaying the reconstruction of a ship radio station (with modern equipment, including a ship terminal for satellite communications). Subject to the co-operation of the competent United Kingdom authorities, arrangements might be made for this radio station to communicate with ships at sea at times agreed in advance.

Finally, the Inter-agency Committee took note of the written information previously forwarded by the International Civil Aviation Organization (ICAO) covering the year 1983 and relating to the regional studies on aeronautical telecommunications carried out by that organization. In connection with World Communications Year, the attention of States and financial agencies will be drawn to the recommendations contained in these and similar studies to be prepared by ICAO in the forthcoming triennium. In addition, 1983 is an ICAO Assembly year. A number of activities are under study, such as an exhibition devoted to aeronautical telecommunications which could be held at ICAO headquarters during the Assembly. ICAO plans to devote an issue of its *Bulletin* in 1983 to aeronautical communications.

3. As to the measures required to secure the effective participation in the national committees of all sectors of activity involved in the development of communications infrastructures, the Inter-agency Committee decided that each organization should address a letter to its corresponding Ministry requesting it to contact the communication authorities responsible for the creation of the national committee in the country in question.

4. The Guide to WCY, which is the basic document for the implementation of WCY programmes, was then approved (see *Telecommunication Journal*, January 1982, pages 13 to 22).

5. The presentation of the WCY Register of Activities also was approved: all the projects undertaken as part of the WCY programme will thus be described and included in the WCY Register of Activities in the format reproduced opposite.

Pilot projects for World Communications Year

As stated in resolution A/RES/36/40 of the United Nations General Assembly, World Communications Year will provide the opportunity for all countries "to undertake an in-depth review and analysis of their policies on communications development" and to stimulate "the accelerated development of communications infrastructures".

World Communications Year will thus be centred not only on consideration of the development of infrastructures, but also on practical activities in that field.

A "list of pilot projects" proposed for the Year was therefore established at the request of a number of potential donors. These projects are aimed at improving infrastructures at national, regional and world-wide levels and will be implemented through international financial contributions. They are concrete projects intended to serve as examples from which valuable lessons may be drawn for other countries or regions and which may stimulate the implementation of similar projects.

This list of 50 projects, which was drawn up by ITU, UPU and ECA, is not exhaustive. Certain donors or recipient governments naturally may propose other projects.

Donors willing to fund all or part of a pilot project, or even several projects (the cost of pilot projects ranges from 100 000 to several million US dollars) are requested as a matter of urgency to contact the WCY secretariat which will supply them with all the necessary information on the procedure to be followed and with the list of pilot projects in the following fields: broadcasting, equipment, maintenance, supervision, maritime service, networks, propagation, training, postal services.

The following information is given on one page in respect of each pilot project:

— project title,
— proposed duration,
— main objectives,
— justification,
— outputs,
— basic categories of inputs,
— estimated costs.

Voluntary contributions to the World Communications Year Fund

By 1 January 1982, voluntary contributions or contributions in kind had been pledged by the following countries: **Bolivia, Bulgaria, Cameroon, Germany (Federal Republic of), India, Indonesia, Japan, Kuwait, Liechtenstein, Luxembourg, Malaysia, Malawi, Mali, Netherlands, Oman, Pakistan, Sweden, United States, Venezuela.**

Many other countries are at present considering the amount and nature of their voluntary contributions to the WCY Fund.

The detailed official list of voluntary contributions will be published on **17 May 1982** on the occasion of the 14th World Telecommunication Day.

Ideas and Achievements

The new Radio Regulations

THE million of pages of documentation printed for the World Administrative Radio Conference (WARC-79) passed through the refining process of intense discussions and negotiations over 74 days and finally resulted in a unique and absolutely indispensable end-product—the new "Radio Regulations", which came into force on 1 January 1982.

Thousands of proposals had been made by the government authorities participating in the Conference to modify and update the 1959 version of the 1524-page Regulations including appendices, resolutions, recommendations and additional regulations. The work was divided among nine committees, which formed working groups and sub-groups to consider and resolve each proposal to arrive at the new and revised Radio Regulations. Committee 5 alone had to deal with 12 832 proposals!

Twelve times the height of the Eiffel Tower

By the time the proposals, counterproposals and agreements had passed through preparatory and conference stages, including 1st series (blues), 2nd series (pinks) and Final Acts (whites)—all in three languages—the entire WARC-79 exercise required the ITU's Department of Conferences and Common Services to type, print, collate and distribute the staggering number of 51 393 608 A4-size pages. If it had been possible to make a single stack of these, the result would have been nearly 12 times the height of the Eiffel Tower (300 m)!

One thousand eight hundred and eighteen registered delegates (1703 from administrations) submitted the written and spoken proposals to a gruelling 1253 plenary, committee, group and sub-group meetings plus countless smaller and informal discussions during the nearly 11-week session.

The ITU Secretariat, by shifting some personnel, adding as few as possible, and going into around-the-clock production towards the end, generally managed to keep abreast of the mountain of work resulting from negotiations and agreements.

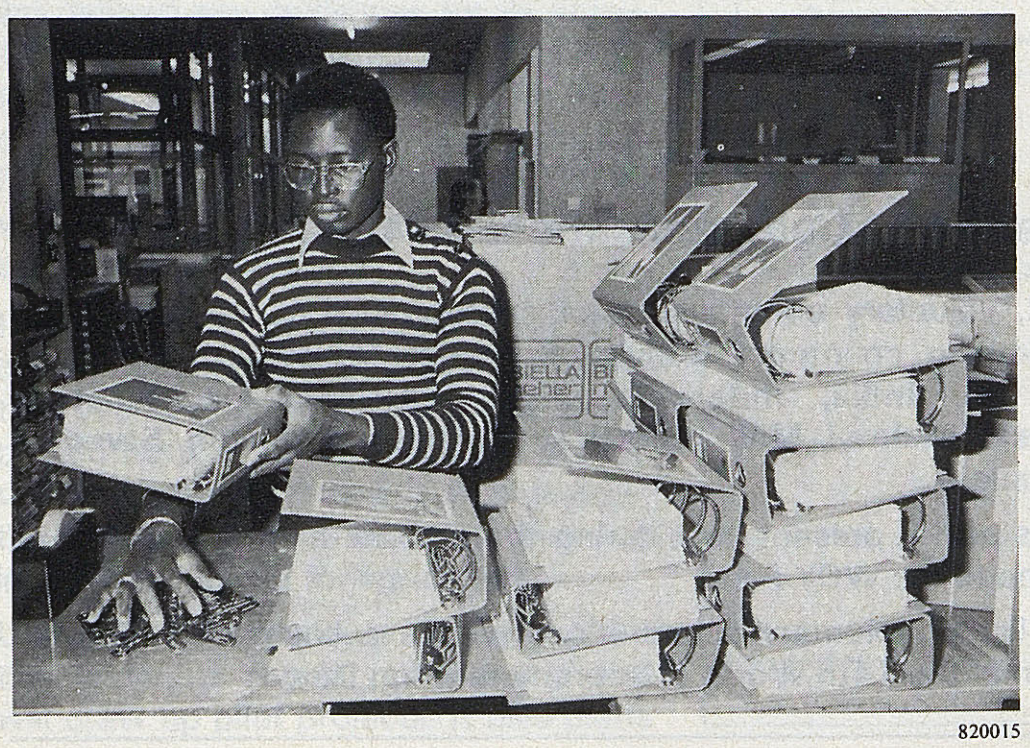
In the end, on the last day of the Conference, 6 December 1979, the Final Acts of the new Radio Regulations were distributed to all delegations, ready for official signature.

A 1716-page book

Once the new Regulations were in final form, the long process of getting the 1716 pages set in type, printed, assembled and shipped began. The 2500 copies needed in French and the 2000 in Spanish were big jobs but were handled by a publisher familiar with the ITU style of documentation and presented no problem.

820016

Volunteer teams in various stages of sub-assembly, assembly and packing of the 10 000 two-volume sets of Radio Regulations so that they could be in the hands of administrations and others involved before they came into force



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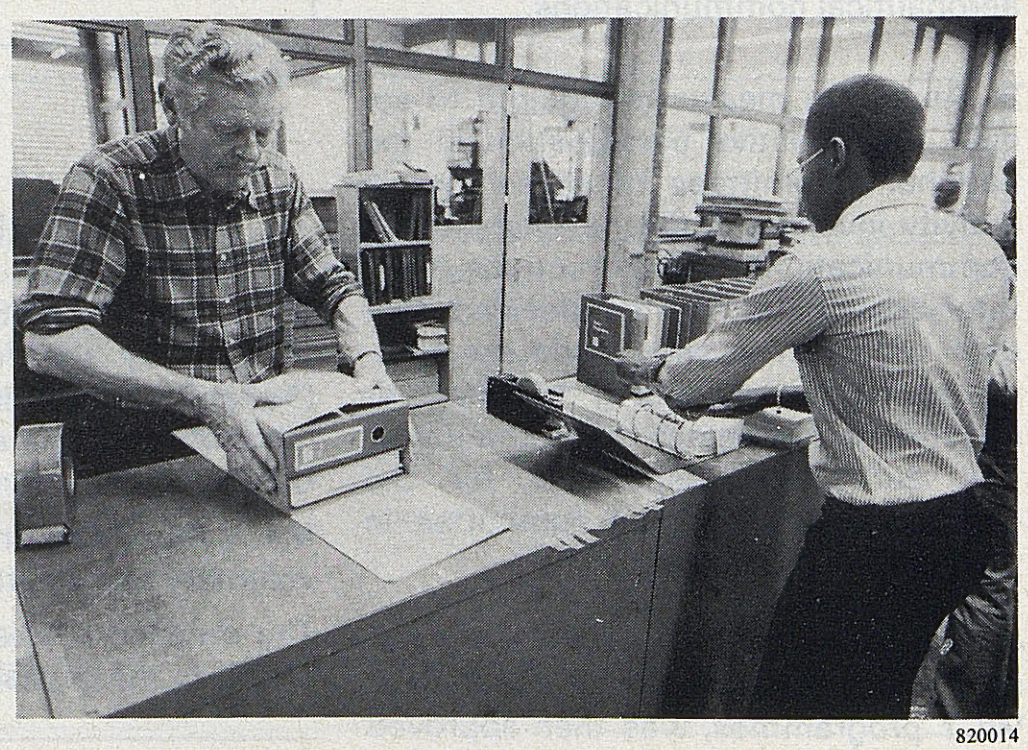


820014

The contract for the English language version—in 10 000 copies—was awarded to a printing-house in Lausanne, Switzerland. That firm had done printing for the ITU before, but not in the special format required by the Radio Regulations.

About six weeks before the deadline to ship the books, the director of the firm realized that his staff, experienced though they were, would simply not be able to assemble the 8 580 000 sheets of Regulations into the two-volume sets in time. While many sections of the books could be sub-assembled mechanically, the 26 stiff cardboard dividers and the 20 foldout tables would have to be added and then placed in the ring binders by hand—a serious bottleneck.

The contract included an amount for putting together and packing the books. So the money was available. It was a question of finding people and time to complete the job quickly.

Willing hands to the rescue

As a member of a non-profit-making humanitarian association, the director of the printing-house knew that the association was looking for ways to raise funds to renovate an old building and create a cultural centre and meeting place for young people in the picturesque Swiss town of Romainmôtier.

He therefore proposed to the association that it should undertake to assemble the Radio Regulations—an unhoped-for way of raising funds for the youth centre and a last-minute chance to get the books out in time.

The members of the association responded as one man to that appeal. Dozens of them with their families and friends descended on the printing plant during nights and weekends to put the books together. Three Lausanne University exchange students from the Congo from the association scholarships joined in and their spontaneous singing brightened the long assembly sessions. The books moved!

The regular employees of the printing house got caught up in the spirit of the project and also offered to work overtime hours. They decided their efforts would be in support of the International Year of Disabled Persons and their overtime pay was given to the Swiss Committee for the Year for its many projects.

Thus, as a result of the combined efforts and goodwill, the Radio Regulations got out in time to administrations and others needing them. And there were unexpected benefits for a youth centre and the handicapped as well.

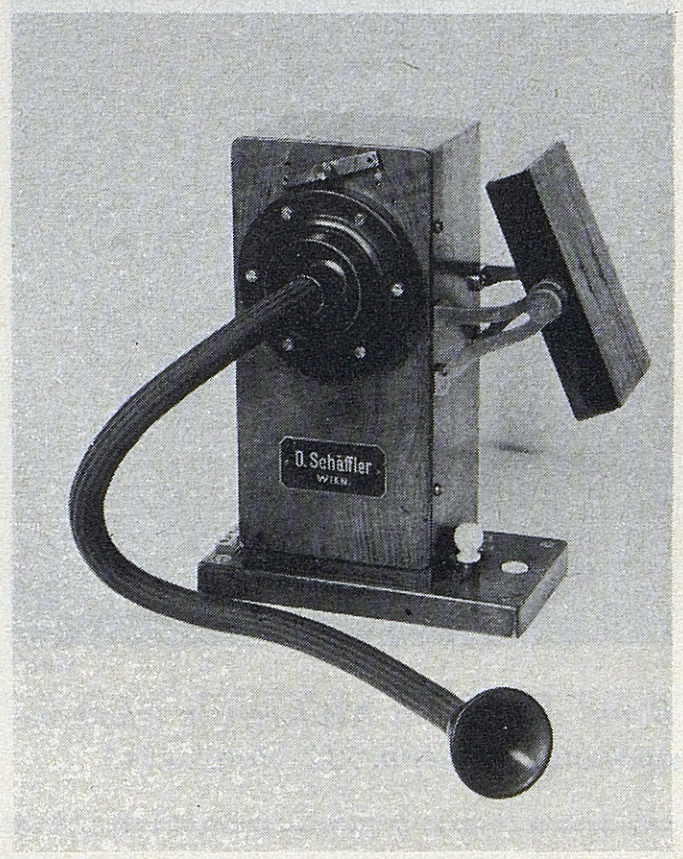
100th Anniversary of the Austrian telephone service

The beginning of the telephone service in Austria can actually be celebrated on two different dates: on 3 June 1881, a licence was issued for a telephone service whose effective range was a 15 km radius around of the St. Stephen Cathedral tower. However, the Austrian PTT considers 1 December 1881 as the official anniversary date because the telephone was effectively implemented on that day. The name of the Company was: *Wiener Privat-Telegraphen-Gesellschaft* and the number of subscribers 154. This figure rose to 11 095 ten years later. At the turn of the century, in 1901, the number of subscribers had reached 34 651 and in 1918 (end of the monarchy) close to 300 000. As evidence of the considerable success of the telephone in Austria it may be remarked that at the moment of this 100th anniversary there are more than three million telephone subscribers for 7.5 million inhabitants.

Among the Wiener Privat-Telegraphen-Gesellschaft's subscribers was Otto Schäffler, a mechanic of German origin who had settled in Vienna. He had been making a certain number of components for the telegraph service and he was entrusted with the job of maintaining and testing the telephone sets; he also received the order for the manufacture of the first telephone exchange in Vienna: it was located at Friedrichstrasse 6, in the 1st district of the city. The first subscriber list was published in the local newspaper in October 1881.

The first public telephone was available on 18 April 1882: it was located on the premises of the Vienna Stock Exchange. A "speak-card" had to be bought for 20 Kreutzer before the telephone set could be used.

Meanwhile, the Consolidated Telephone Construction and Maintenance Company Limited of London (later Telephone



820017

Table telephone (1884) manufactured by the firm Otto Schäffler

820018

Berggasse telephone exchange, Vienna, 1914

Company of Austria) had obtained permission to install and operate telephone networks in several cities of the Empire. On 12 August 1882 it was possible to establish regular contact with Graz, Prague and Trieste. Other cities followed in 1883. The longest circuit was Vienna—Trieste (506 km), in fact one of the longest in Europe: it had an intermediate exchange at Graz.

820019

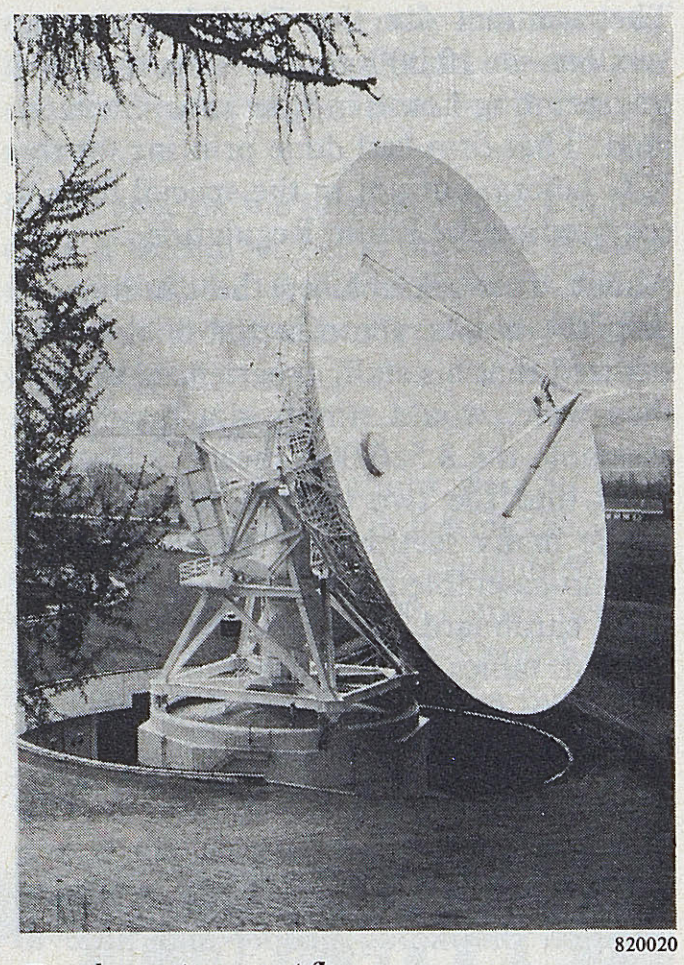
Bomb damage at Neutorgasse telephone exchange in Vienna, 12 March 1945

The telephone networks were taken over by the State on 29 June 1887. During that same year, the first Regulations were issued which emphasized the role of the telephone as a means for distribution and registration of telegrams. That was its primary duty. Development of the networks proceeded at a steady pace and most cities were linked within a relatively short time.

The first public coin-operated telephone was introduced in 1903 and was installed in the Vienna Southern Railway station.

The first semi-automatic telephone service was introduced in Graz on a trial basis in 1910 and served 2000 individual subscribers and 1200 companies. This system proved satisfactory and it was introduced in Vienna at the beginning of 1914. The modernization of the national network was resumed in 1920 after World War I and the fall of the monarchy.

World War II brought much damage to the telephone network: it was decided to adopt a modern system on rebuilding. System "48" was chosen—this system which featured billing by the use of pulses was the background on which



820020

Earth station at Aflenz

eventually STD was developed. This was called system "51" (1951) and necessitated the laying of coaxial cables and microwave relay techniques. The national network was completely converted to automatic working by 1972 and most parts of the world can now be reached by international subscriber dialling.—*Austrian Administration.*

ITU Film Library

Ref: ITU-237

Pays — Country — País: FRANCE — FRANCIA (1978)

Titre — Title — Título: LA KATYDIDE (The katydid — La cigarra)

Format — Size — Tamaño: 16 mm

Durée — Duration — Duración: 18 min

Langue — Language — Idioma: français — French — francés

Observations — Remarks — Observaciones: couleur — colour — color

Sujet — Subject — Asunto:

A l'occasion de la préparation d'une thèse où l'on fait connaissance d'un insecte, la katydide, doté par la nature d'extraordinaires facultés de communication, un jeune homme découvre la station de télécommunications par satellites de Pleumeur-Bodou et le Centre national d'études des télécommunications de Lannion. Ce film montre que les télécommunications font partie de notre vie quotidienne et donne un aperçu de la technologie mise en œuvre dans le domaine des télécommunications par satellites.

Il s'adresse à tous les publics.

While preparing a thesis on a strange new insect, the "katydid", possessing remarkable communication faculties, a young man discovers the Pleumeur-Bodou telecommunication satellite station and the *Centre national d'études des télécommunications* at Lannion. This film shows how telecommunications form part of our daily life and gives an insight into telecommunication-satellite technology.

Audience: general.

Con motivo de la preparación de una tesis en la que se observa con detalle a un insecto, la cigarra, dotado por la naturaleza de extraordinarias facultades de comunicación, un joven descubre la estación de telecomunicaciones por satélite de Pleumeur-Bodou y el *Centre national d'études des télécommunications* de Lannion. Esta película muestra que las telecomunicaciones forman parte de nuestra vida cotidiana y da una idea general de la tecnología utilizada en el sector de las telecomunicaciones por satélite.

Carácter: general.

Editeur — Producer — Editor: PTT, France

Date d'arrivée à l'UIT — Date of arrival at ITU — Fecha de recepción en la UIT: 1979

special "optical fibres"

(Part 2)*

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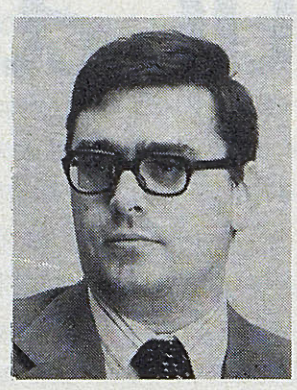
* Part 1 (Optical components) was published in November 1981.

Transmission systems using optical fibres

by

A. MONCALVO

Centro Studi e Laboratori Telecomunicazioni (CSELT)
Turin



and

R. PIETROIUSTI

Società Italiana per l'Eserzicio Telefonico (SIP)
Rome, Italy

1. Introduction

In many countries the first generation of communication systems on multimode optical fibres is today carrying commercial telephone traffic. This result comes at the end of a decade of intensive research effort, in which an understanding of the underlying basic phenomena has led to the development of all the system building blocks.

This paper is concerned with the final segment of this effort, the system design, in which, starting from the specific properties of the different blocks, the performances of a transmission system using optical fibres are evaluated. An account of the problems encountered in this process is outlined and the different solutions proposed are discussed.

2. Digital transmission systems

The greatest attention has generally been devoted to digital systems, as a consequence of both the suitability of optical systems to carry digital information and the world-wide tendency to evolve from the present analog toward a fully integrated digital network.

2.1 System model

The block diagram of an optical fibre digital transmission system is given in figure 1.

At the transmitting terminal, a line coder converts the sequence of binary symbols (data in) with rate f_0 in a sequence of symbols with rate $f_s = \frac{1}{T}$ having suitable properties.

This signal modulates, through a driver circuit, the intensity of the light of an optical source, a light emitting diode (LED) or a laser, so that an optical pulse of rectangular shape with a given duty cycle is associated with each input symbol. As the emitter power is peak-limited, the choice of the duty cycle results from a trade-off between the increase of the launched pulse energy E_i and the noise enhancement due to the equalizing network at the receiver. Values currently used are between 50 and 100%.

During propagation, the pulses suffer attenuation and distortion. In this respect, the fibre can be modelled as a baseband system with a transfer function approximated as:

$$H_F(f) = e^{-K[\alpha l + 3(f T f_n)^2]} \qquad (1)$$

where

$K = \frac{1}{10} \log e$

l is the fibre length (km)

α is the attenuation (dB/km)

$f_n = \frac{1}{TB}$ is the ratio between the symbol rate $\frac{1}{T}$ and the -6 dB electrical bandwidth of the fibre.

B takes into account both modal and material dispersion and can be approximated by:

$$B = \left[\sqrt{\frac{1}{B_0^2} l^{2E} + \left(\frac{10^6 M \Delta\lambda}{0.44}\right)^2 l^2}\right]^{-1} \qquad (2)$$

where

B_0 is the bandwidth (MHz) of 1 km of fibre due to modal dispersion

E is the dependence factor of the modal bandwidth on length

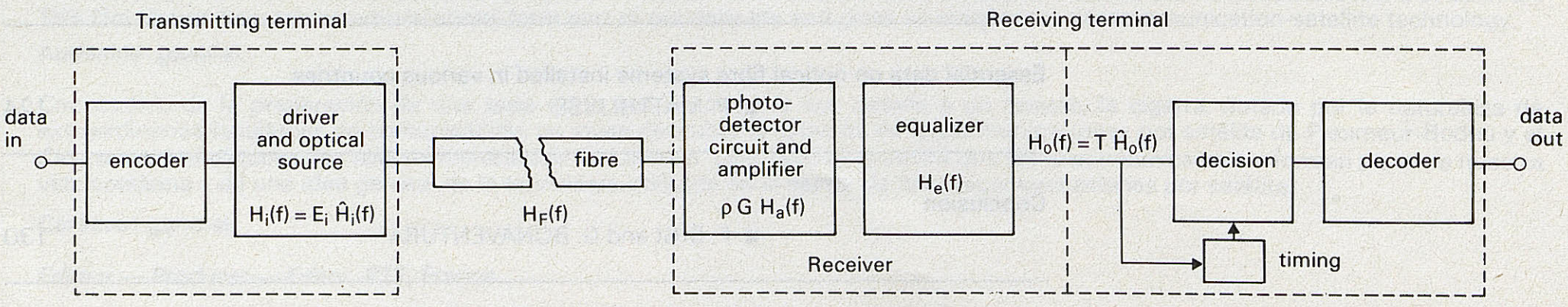


Figure 1 – Block diagram of an optical fibre digital transmission system

Table 1—Typical parameters of semiconductor optical sources

item	LED 1st window	laser 1st window	LED 2nd window	laser 2nd window	unit
peak power injected into fibre (50 μm core; 0.2 N.A.)	0.05 or more	1 or more	0.05	1	mW
threshold current	—	50-100	—	100-200	mA
FWHM linewidth	30-50	2-5	60-120	10	nm
–6 dB electrical bandwidth	50	200 or more	50-100	200 or more	MHz
typical application	up to 50 Mbit/s	up to 1 Gbit/s	up to 150 Mbit/s	up to 1 Gbit/s	

M is the material dispersion coefficient (ps/nm · km), and $\Delta\lambda$ is the source linewidth (nm).

The pulse energy E_0 at the fibre output is given by:

$$E_0 = E_i \, e^{-K\alpha l}$$

At the receiver the optical pulses are converted in electrical form by a PIN diode or an avalanche photodiode (APD) photodetector, amplified and equalized to achieve the maximum signal-to-noise ratio.

The transfer function of the receiver can be written as $\rho \, G \, H_a(f)$, where ρ is the photodetector responsitivity in A/W, G is the mean avalanche gain ($G = 1$ with PIN) and $H_a(f)$ is the transfer function of the photodetector circuit and of the amplifier.

The equalizer $H_e(f)$ is generally designed to deliver an ouput pulse $h_0(t)$ without intersymbol interference.

The equalized signal is regenerated using the time reference extracted from the signal itself and decoded to recover the original information sequence (data out).

2.2 Source choice and driver design

Both lasers and LEDs have found specific areas of convenient application in digital optical systems: their typical parameters are summarized in table 1.

The optical power emitted by semiconductor sources can be simply controlled by the applied current. In the case of an LED operating with two-level modulation, only switching of the driving current between near zero and some maximum values is required. Since the input impedance of the LED is typically a few ohms in parallel with some hundreds of picofarads, a single stage current amplifier using a microwave transistor can deliver the required steep current pulse. Two possible schemes, where R-C compensation networks are shown, are reported in figure 2. [1] By a careful tuning of the network elements, rise and fall times of 2-3 ns can be achieved.

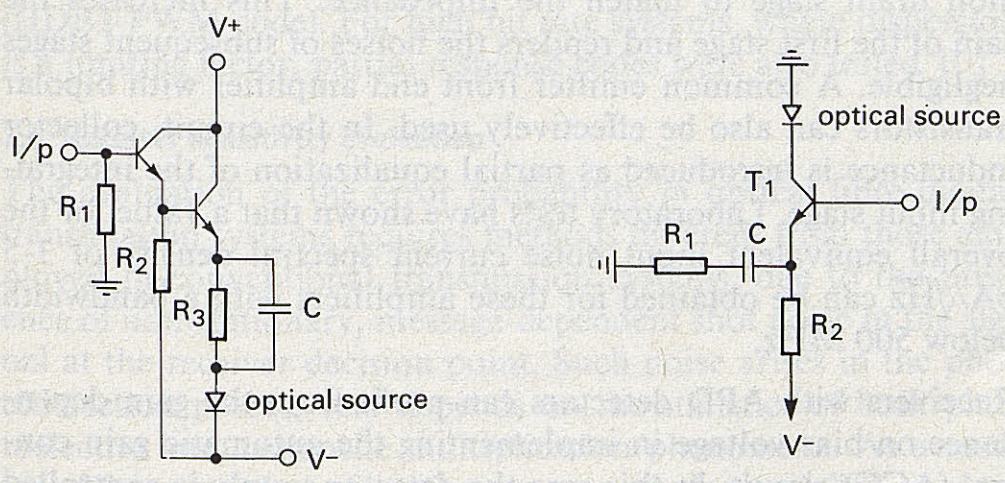


Figure 2—Schematic diagram of LED drivers for digital signals

The same effect is obtained by placing an emphasis network at the signal input: this solution not only improves the pulse rise time, but can also compensate for the cut-off due to the optical channel. Temperature and aging do not significantly affect the LED characteristics, therefore there is no need for control circuits for the emitted power.

As regards the laser, the quiescent operating point is usually set above the threshold with a DC bias, on which the modulating pulse is superimposed. The driver can be implemented with the circuits already described for LEDs up to rates in the order of 50 Mbit/s. For systems at higher data rates, voltage amplifiers can be used into a 50 Ω load. In these cases the dynamic impedance of optical sources is raised (to 50 Ω) in the bandwidth considered, to ensure a good matching. The performance, such as rise and fall time and ringing, is determined by the bandwidth and shape of the amplifier response.

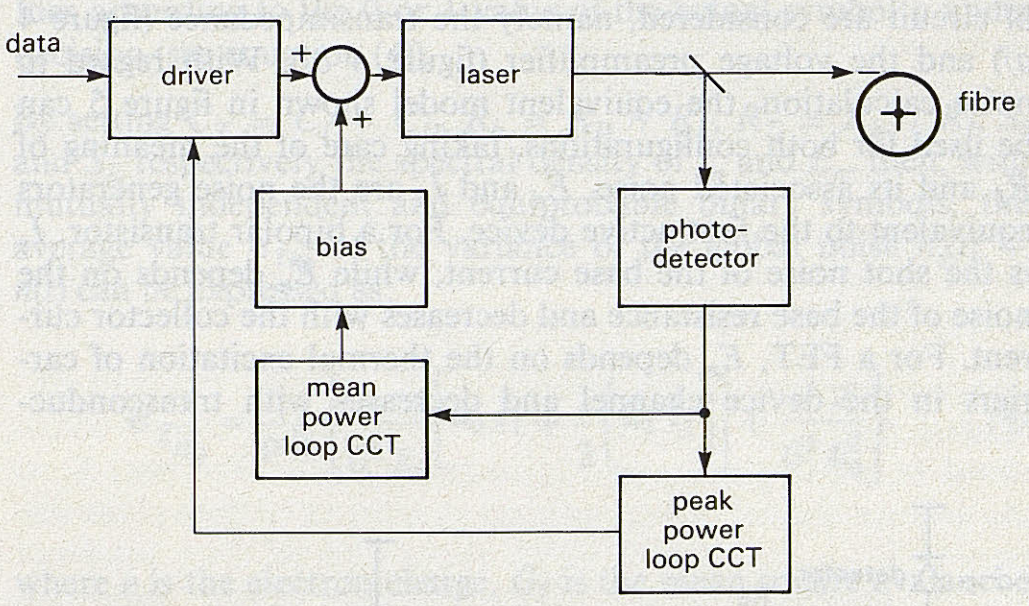


Figure 3—Block diagram of laser power automatic control system

The sensitivity of laser characteristics to temperature and aging requires an automatic level control circuit in the transmitter, to ensure constant output power and modulation depth by varying the bias or the modulation current. Feedback circuits are used to compare a fraction of the light injected into the fibre to a reference signal, as shown in figure 3. The simplest arrangement maintains the mean optical power constant by adjusting the

bias level: this solution requires a DC loop only. Information relating to the changes in the slope above the threshold can be obtained from changes in the peak-to-peak power, directly measured by a high-speed detector and an amplifier almost equal to the regenerator front-end. The same information can be obtained from the line at the rate frequency in the spectrum of a return-to-zero signal, [2] or, using simpler circuits, from the level variations of a low-frequency square wave superimposed on the bias signal. [3]

2.3 Detector choice and receiver design

Both PIN and APD photodetectors can be used in the receiver front-end. In the first window, silicon (Si) APD is the most suitable device, as the optical power saving due to the avalanche gain is well worth the use of a high bias voltage. In the second window, the performances of germanium (Ge) and quaternary APD are at present much worse, due to the noise generated in the avalanche process and to the dark current, therefore a PIN detector coupled to a field effect transistor (FET) amplifier [4] can be a viable alternative solution. The main detector parameters relevant to the system design are summarized in table 2.

Table 2—Typical parameters of optical detectors

item	Si APD	Ge APD	III-V PIN	unit
responsivity	0.7	0.6	0.4	A/W
useful gain	100	10	1	—
dark current	1	100	10	μA
excess noise exponent	0.4	1	—	—

The preamplifier following the detector should be carefully designed in order to achieve high gain and low noise. Two types of circuit are considered, namely the transimpedance (figure 4 *a)*) and the voltage preamplifier (figure 4 *b)*). With regard to noise calculation, the equivalent model shown in figure 5 can be used for both configurations, taking care of the meaning of R_F and its associated noise. E_n and I_n are the noise generators equivalent to the first active device. For a bipolar transistor, I_n is the shot noise of the base current, while E_n depends on the noise of the base resistance and decreases with the collector current. For a FET, E_n depends on the thermal excitation of carriers in the device channel and decreases with transconductance; I_n represents either the shot noise of the gate current or the capacitance-coupled thermal noise.

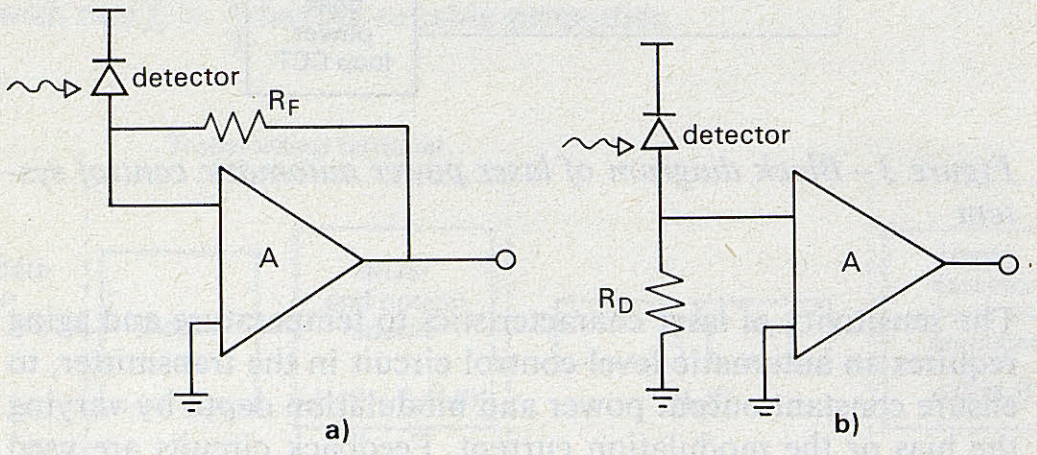


Figure 4—Block diagram of preamplifier circuits:
a) *transimpedance;* b) *high impedance*

Careful optimization is required to choose the feedback resistance R_F: increasing values improve the signal-to-noise ratio, but also raise input impedance, thus enhancing the integrating effect of the input capacitance. [5] Laboratory tests have shown that an overall equivalent input noise current spectral density as low as 1.5 pA/$\sqrt{\text{Hz}}$ can be obtained for a transimpedance preamplifier using bipolar transistors, with a bandwidth below 50 MHz and 80 kΩ for the feedback resistance. For a 100 MHz bandwidth and a 5 kΩ transimpedance, a spectral density of 5 pA/$\sqrt{\text{Hz}}$ can be achieved. The experimental results obtained on a transimpedance preamplifier using FET as a first stage have not proved so satisfactory.

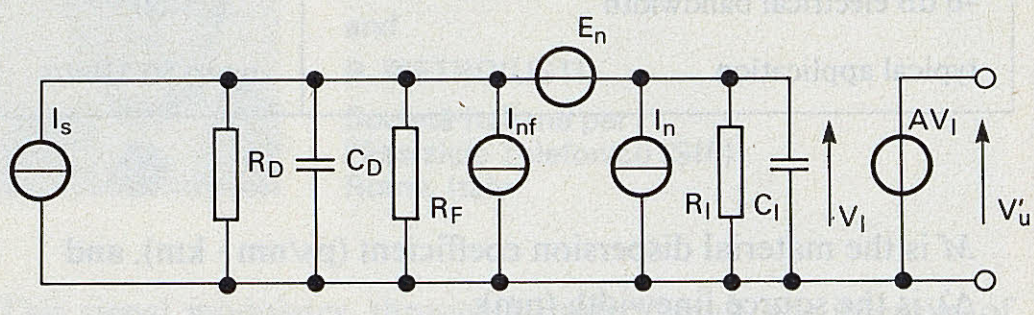


Figure 5—Noise equivalent circuit for the photodetector and the amplifier

I_s = *equivalent optical signal current generator*
R_D = *photodetector bias resistor*
C_D = *photodetector junction capacitance*
E_n = *amplifier equivalent noise voltage generator*
I_n = *amplifier equivalent noise current generator*
C_I = *amplifier input capacitance*
R_I = *first stage input resistance*
R_F = *amplifier transimpedance*
I_{nF} = *equivalent thermal noise current generator corresponding to* R_D // R_F
A = *amplifier open loop voltage gain*

The voltage amplifier is more suited to those systems where high bandwidth (above 100 MHz) is required. At these frequencies, propagation delay in the closed loop of the feedback amplifier reduces the phase margin and becomes a significant drawback. The high impedance preamplifier is a simpler and cheaper circuit but needs a differentiating network to equalize the integrating effect due to the total input capacitance. A circuit configuration which gives a good noise performance is a cascade of a first common source FET stage followed by a common drain stage to match the impedance. This increases the gain of the first stage and renders the noises of subsequent stages negligible. A common emitter front end amplifier with bipolar transistors can also be effectively used. In the circuit, collector inductance is introduced as partial equalization of the integrating input stage. Laboratory tests have shown that a value for the overall equivalent input noise current spectral density of 3-5 pA/$\sqrt{\text{Hz}}$ can be obtained for these amplifiers with a bandwidth below 500 MHz.

Receivers with APD detectors can profit from the gain dependence on bias voltage in implementing the automatic gain control (AGC) circuit. In this case the detector supply is controlled by the same voltage that acts, in a feedback loop, on voltage-controlled electrical attenuators.

2.4 Timing acquisition

In every regenerator timing information is required to reconstruct the digital signal properly. Several solutions described in the literature to extract the timing waveform from the data can be used effectively in optical links. They include in general a non-linear device sensitive to signal transitions and a circuit tuned to the bit rate to smooth out jitter in the recovered waveform. This latter is usually implemented by a phase-locked loop to achieve very narrow noise bandwidth. Studies on jitter accumulation [6] have shown that a contribution arising from shot noise exists, but can be kept within a tolerable limit by a suitable circuit design.

2.5 Line coding

An important problem in the design of digital transmission systems on optical fibres is the choice of the line code. In fact, it must fulfil many requirements at the same time, such as: suitable shaping of the power spectral density, timing information recovery, in-service error monitoring at terminals and repeaters, frame alignment and reduced error extension in decoding.

Binary codes are generally preferred to prevent possible problems related to the non-linearity and temperature dependence of the optical source characteristics.

As in optical systems decoupling is performed by RC networks, the reduction of low frequency spectrum content is much less important with respect to copper cable systems, where transformers are used, so that proper signal characteristics can be achieved by means of scramblers. In this case error control can be performed by inserting parity bits [7] or complementary bits [8] in the transmitted data stream.

Two-level block codes of the *nB mB* type, that convert blocks of n bits into blocks of m bits with $m>n$ in such a way that the difference between the number of transmitted marks and spaces is on average zero, fulfil the above-mentioned requirements, with a limited amount of added redundancy.

Among the various codes of this class of the 5B6B is generally considered the most advantageous trade-off between coding complexity and added redundancy. With the 6B8B code a very simple error monitoring at dependent repeaters can be achieved by detecting the DC component changes of the output of a bistable circuit switched by each mark of the transmitted signal. [9]

When the pulse broadening penalty is not severe, a 1B2B code, such as the mark inversion (CMI) code already used in the digital interfaces at 140 Mbit/s, could be preferred for ease of implementation. A pulse width modulation (PWM) format has recently been proposed [10] for mapping the symbols of the high density bipolar 3 (HDB3) code, standardized for 8 and 34Mbit/s digital interfaces, in two-level pulses with different duty cycles (HDB3-PWM code). For high bit rate systems, where dispersion is a limiting factor, partial response codes were also tested. [11]

2.6 Receiver sensitivity evaluation

The evaluation of the error probability in optical fibre digital transmission systems requires methods different from those employed in conventional transmission systems, due to the presence of non-stationary, message-dependent shot noise in the signal at the receiver decision point. Such noise arises in the photodetection process and depends on the statistics of both photoelectric and avalanche multiplication phenomena. As a matter of fact, the photodetection process can be modelled as a sequence of two steps. In the first step, the incident light power is converted into the "primary" electrons, whose generation times form a Poisson process with intensity function proportional to the incident optical power. In the second step, the primary electrons enter the avalanche multiplication mechanism so that each primary electron is replaced by a random number of "secondary" electrons.

The exact evaluation of error probability at the receiver output has been studied by several authors (see, for example [12, 13]) and involves tedious calculations. The methods studied for an approximate evaluation are essentially based on the Chernoff bound method [12] or on the shot noise Gaussian approximation. [12, 14] The Gaussian approximation is particularly attractive because it is very simple and predicts error probability fairly accurately; moreover, in the absence of intersymbol interference, it allows analytical approaches [14, 15] in the required optical power evaluation which provide insight into the system design. Following this approximation the signal $v(t)$ at the receiver output can be decomposed as:

$$v(t) = \sum_{n=-\infty}^{+\infty} a_n h_0 (t-nT) + d + n_d(t) + n_s(t) + n(t) \qquad (3)$$

$\sum_{n=-\infty}^{+\infty} a_n h_0 (t - nT)$ represents the information carrying signal, $n(t)$ is the thermal noise, $n_d(t)$ and $n_s(t)$ represent two additive Gaussian shot noises due, respectively, to the dark current and to the process of the received optical power photodetection, and d is the average value corresponding to the dark current. For the sake of simplicity, the dark current, and hence d and $n_d(t)$, will reasonably be assumed as negligible in the following evaluations.

The shot noise $n_s(t)$ represents the main difference between conventional and optical fibre digital transmission systems since it is non-stationary and correlated with the information-carrying signal. The value of the shot noise variance in the decision instant depends on the particular transmitted symbol stream; in the following its value is averaged over the symbols preceding and following the decided one, thus obtaining two different values according to the 0 or 1 value of the actual symbol a under decision (see equation (4)).

By setting $C_T = C_I + C_D$, $R_b = R_D \,//\, R_F$, $R_T = R_b \,//\, R_I$, S_I and S_E respectively the spectral density of I_n and E_n, then, with mutually independent and equiprobable binary symbols, the average value σ_{Ta_0} of the variance of the global noise $n_s(t) + n(t)$ can be expressed as:

$$\sigma^2_{Ta_0} = \frac{1}{\rho\, 2}\left\{\frac{G_2\, e\, \rho}{G^2\, E_0}\left[a_0\, I_1 + \frac{1}{2}\left(\Sigma_1\, I_1\right)\right] + \frac{e^2\, Z}{G^2\, E_0^2}\right\} \qquad (4)$$

where e is the electron charge, G_2 is the mean square avalanche gain while the integrals I_1, I_2, I_3, the sum Σ_1 and the parameter Z are defined in [15]. It is worth noting that Z is dimensionless and represents the overall thermal noise occurring at the receiver output.

As far as the mean square avalanche gain is concerned, it can be determined by the model of the avalanche multiplication process proposed by McIntyre: [16]

$$G_2 = G^2\left[\delta G + (1-\delta)\left(2 - \frac{1}{G}\right)\right] \qquad (5)$$

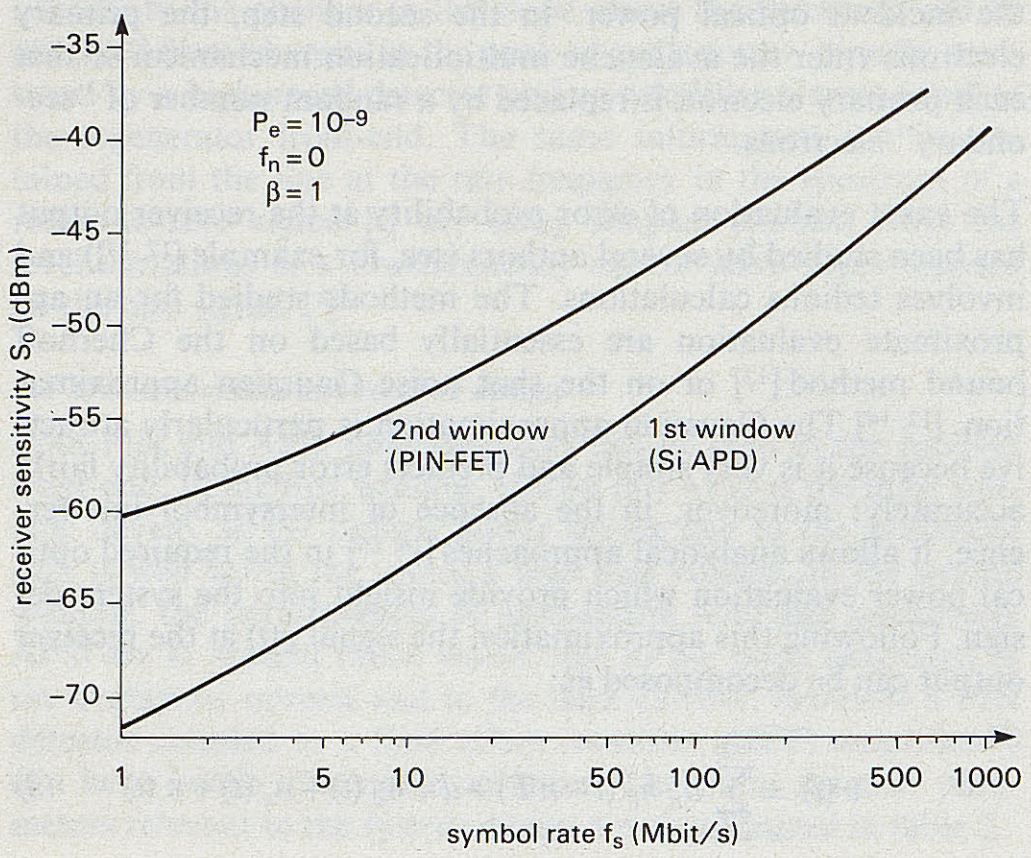


Figure 6 – Receiver sensitivity S_0 versus symbol rate f_s for first and second window receivers

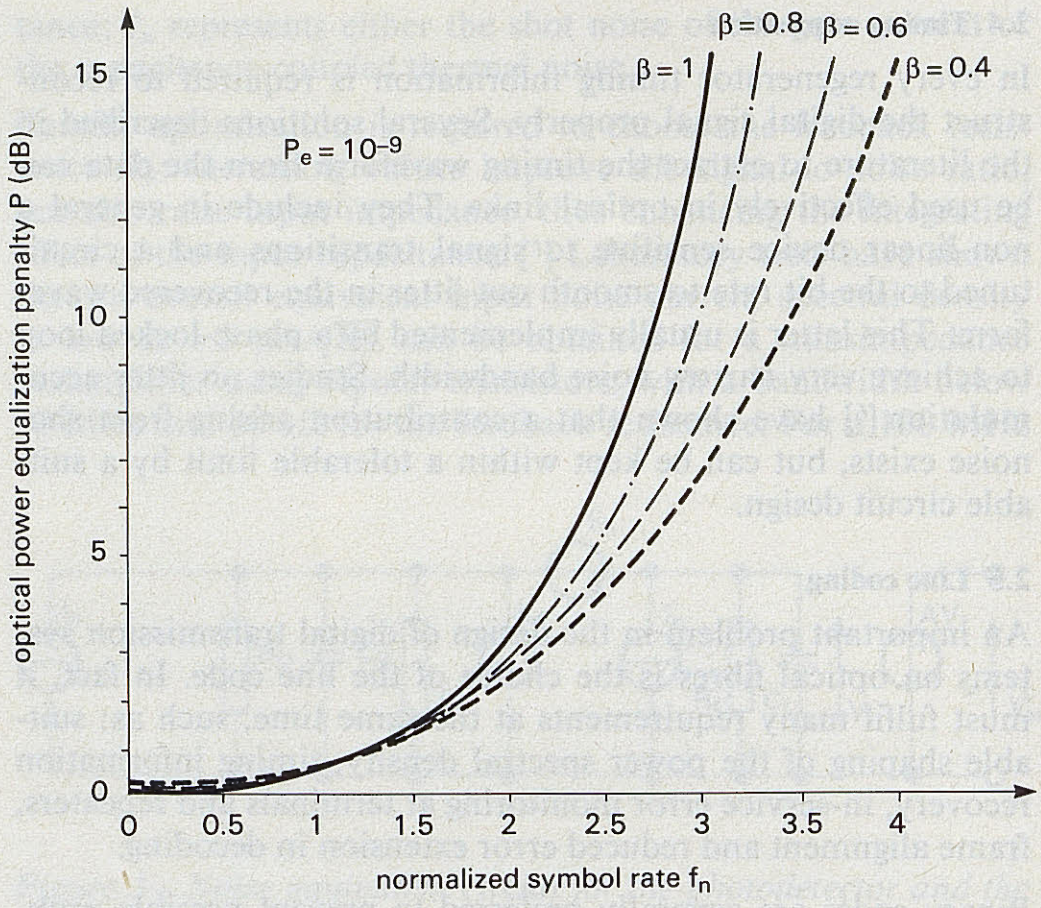


Figure 7 – Optical power equalization penalty versus the normalized symbol rate f_n

Where δ is the ratio between the ionization coefficients of holes and electrons ($\delta = 0.02 \div 0.1$ for silicon and $\delta = 2$ for germanium). An approximation usually adopted for G_2 is $G_2 = G^{2+x}$ when x is a constant equal to $0.3 \div 0.5$ for silicon APD and $0.8 \div 1$ for germanium APD.

The first term of the sum in *(4)* is directly proportional to G, while the second is inversely proportional: therefore at a value G_0 of G (hereafter referred to as optimum gain) total noise power $\sigma^2_{Ta_0}$ becomes minimal.

In the absence of intersymbol interference and adopting the above-mentioned approximation for G_2, it is possible, for any received and equalized pulse shapes, to obtain from *(4)* an explicit expression for G_0 and for the corresponding minimum value of the energy E_0 required to achieve a given error rate.

The minimum average optical power $E_0/2T$ is normally referred to as the "receiver sensitivity" and, expressed in dBm, will be denoted by S.

For a given value of the symbol rate f_s and the "normalized" symbol rate $f_n = f_s/B$, the receiver sensitivity S can be considered as constituted by two contributions. The first one, S_0, is the average optical power required in absence of fibre pulse dispersion ($f_n = 0$), i.e. with direct connection of the transmitter and the receiver. The second one, hereafter called "dispersion equalization penalty", P, is the additional optical power required to compensate for the sensitivity loss resulting from the received pulses overlapping due to the finite bandwidth of the fibre. It is worth noting that the penalty P depends on the shape of the received pulses but not on the bit rate.

Numerical results are reported for some systems, based on the following assumption:

- the transmitted pulses are rectangular with 50% duty-cycle;
- the overall transfer function is a raised cosine function with roll-off β;

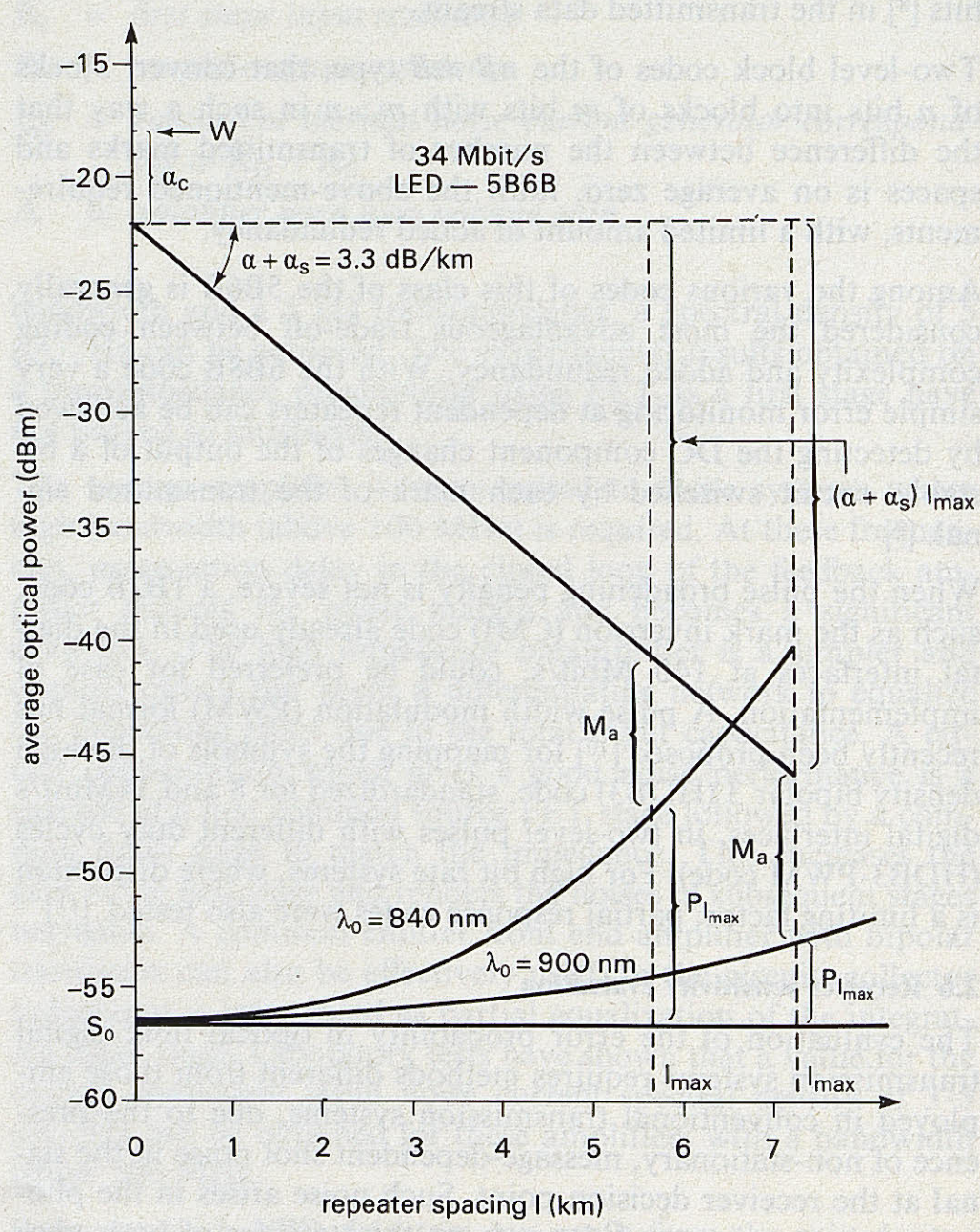


Figure 8 – Graphic evaluation of repeater spacing for a 34 Mbit/s system, using an LED source at 850 or 900 nm, 5B6B line code and an APD detector

– the receiver for the first window ($\lambda_0 = 820 \div 900$ nm) has the following characteristics:

  $\rho = 0.6$ A/W, $x = 0.5$, $R_D = 1\text{M}\Omega$, $C_D = 3$ pF, voltage preamplifier with $R_I = 10$ kΩ, $C_I = 5$ pF and 8 $\text{m}\Omega^{-1}$ transconductance;

– the receiver for the second window ($\lambda = 1300$ nm) is a PIN + FET with the following characteristics:
  $\rho = 0.45$ A/W, $R_D = 1$ MΩ, $R_I = 10$ kΩ, $C_T = 0.4$ pF, 8 $\text{m}\Omega^{-1}$ transconductance.

Figure 6 shows the receiver sensitivity S_0 (in absence of fibre pulse dispersion, $f_n = 0$) versus the symbol rate f_s for $\beta = 1$ and $P_e = 10^{-9}$. Figure 7 shows the dispersion equalization penalty P versus f_n for several values of β, for $\beta \neq 1$ the penalty is referred to $\beta = 1$ and $f_n = 0$. It can be seen that for low values of f_n the penalty is practically independent of β, while for high values of f_n the penalty decreases as β decreases. On the other hand, it must be noted that the choice of β is also affected by circuit complexity and timing recovery, which are easier for high values of β. A good compromise in the presence of fibre dispersion can range between 0.6 and 1.

2.7 Repeater spacing evaluation

When the transmitter charcteristics, fibre characteristics and receiver sensitivity are known, the repeater spacing evaluation involves a simple process of optical power budgeting.

With $W = 10 \log_{10} (E_i\ 10^3/2T)$ being the mean optical power (in dBm) launched into the fibre, α_c the overall loss (in dB) in the connectors of the equipment, α_s the splice loss (in dB/km) and M_a a safety margin (in dB), the maximum repeater spacing l_{max} can be deduced from the following expression:

$$S_0 + P_{l_{\max}} = W - \alpha_c - (\alpha + \alpha_s)\, l_{\max} - M_a \qquad (6)$$

where $Pl_{\max}$ denotes the equalization penalty corresponding to $l_{\max}$ (P depends on l through f_n, see equation *(2)*).

The safety margin M_a includes operating margin and allowance for possible source and modal noises and for repeater impairments, such as equalization error, noise degradations and eye opening impairments.

An example of graphic use of equation *(6)* is given, for a 34 Mbit/s system, in figure 8 where receiver sensitivity has been reported versus link length l. The example refers to a system using an APD, an LED source operating at $\lambda_0 = 840$ nm or $\lambda_0 = 900$ nm and a fibre with modal bandwidth $B_0 = 200$ MHz. The other characteristics assumed for the system can be found in table 3. It can be seen that, for a 3 dB/km fibre attenuation, the resulting repeater spacing is 5.6 km at $\lambda_0 = 840$ nm and 7.2 km at $\lambda_0 = 900$ nm.

The graphic method described above is very useful in the evaluation of repeater spacing for systems with specified symbol rate and well-defined fibre characteristics. For the evaluation of

Table 3 – System parameters

linewidth of source spectrum at half-height $\Delta\lambda$ (nm)	55 for LED at $\lambda_0 = 840$ nm 35 for LED at $\lambda_0 = 900$ nm 90 for LED at $\lambda_0 = 1300$ nm 2 for laser at $\lambda_0 = 820$ nm 10 for laser at $\lambda_0 = 1300$ nm
average optical power launched into the fibre W (dBm)	−18 for LED −3 for laser at $\lambda_0 = 820$ nm −6 for laser at $\lambda_0 = 1300$ nm
line code	5B6B
shape of launched pulses	rectangular with duty-cycle 50%
first window APD receiver sensitivity S_0 ($P_e = 10^{-9}$) (dBm)	−42 for 564.992 Mbit/s −49.5 for 139.264 Mbit/s −56.5 for 34.368 Mbit/s
PIN-FET receiver sensitivity S_0 ($P_e = 10^{-9}$) (dBm)	−37 for 564.992 Mbit/s −45.5 for 139.264 Mbit/s −49.5 for 34.368 Mbit/s
shape of the equalized pulse	raised cosine with roll-off $\beta = 0.6$
material dispersion coefficient M (ps/nm·km)	100 at $\lambda_0 = 840$ nm 80 at $\lambda_0 = 900$ nm 5 at $\lambda_0 = 1300$ nm
overall loss in connectors and splices of equipments α_c (dB)	4
equivalent line splicing loss α_s (dB/km)	0.3
safety margin M_a (dB)*	7 for LED 9 for laser
dependence factor E of modal bandwidth on fibre length	$0.6 \div 0.8$

* This parameter depends to a large extent on the system components and on the actual procedure used in the system design. The figures given here must be considered as just an example.

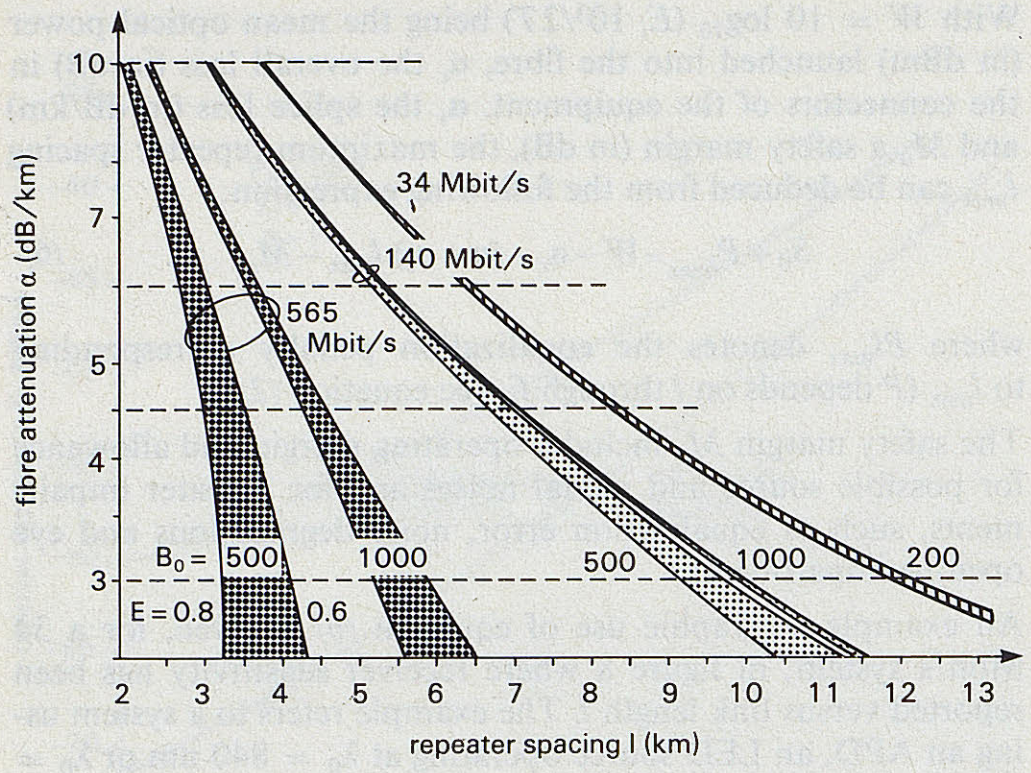


Figure 9 – Fibre attenuation versus repeater spacing for 34, 140 and 565 Mbit/s first window systems using APD laser sources and 5B6B code

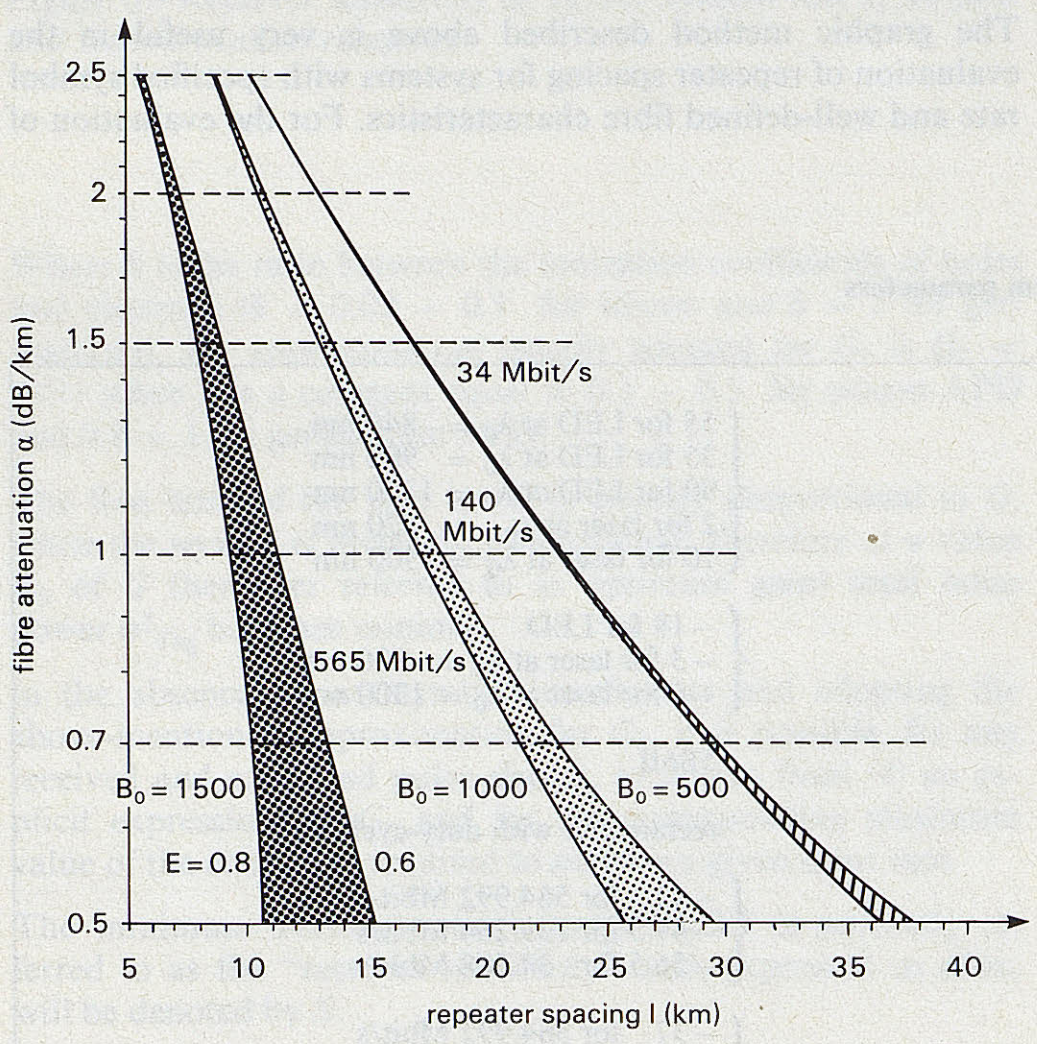


Figure 10 – Fibre attenuation versus repeater spacing for 34, 140 and 565 Mbit/s second window systems using PIN-FET receivers, laser sources and 5B6B code

the repeater spacings achievable at different symbol rates with different fibre characteristics, equation *(4)* can be translated in a suitable computer program. Figures 9 and 10 report, for the first and second window respectively, the achievable repeater spacing versus the fibre attenuation for the 34, 140 and 565 Mbit/s systems using laser sources and having the characteristics summarized in table 3. The values considered for the modal bandwidth B_0 are 200, 500, 1000 and 1500 MHz while the factor E ranges between 0.6 and 0.8. The results reported refer, for each system, to proper values of B_0 as greater values do not give a significant increase in repeater spacing. As can be seen, in the first window and for a 3 dB/km fibre attenuation, the repeater spacing is equal to about 12 km for the 34 Mbit/s system, ranges between 9 and 10 km for the 140 Mbit/s system and between 5 and 6 km for the 565 Mbit/s system. In the second window and for a 0.7 dB/km fibre attenuation, the repeater spacing is of about 30 km for the 34 Mbit/s system, ranges between 21 and 24 km for the 140 Mbit/s system and between 10 and 14 km for the 565 Mbit/s system.

3. Analog transmission systems

Analog transmission systems on optical fibres are designed mainly for the transmission of video signals. They are very attractive for this application because of their circuit simplicity and low cost in comparison with digital video terminals.

3.1 Modulation techniques

The analog signal can be transferred in the intensity modulation (IM) of the optical carrier by varying the current flowing in the optical source, around a suitable bias level.

The information signal can be transmitted directly in the baseband front (D-IM) or can be translated on an electrical carrier, by means of amplitude (AM-IM) or frequency (FM-IM) modulation.

A sequence of pulses can also be used as carrier, by varying a suitable parameter, such as pulse frequency (PFM-IM), pulse width (PWM-IM), pulse position (PPM-IM), or pulse interval (PIM-IM).

3.2 Transmitter and receiver design

The optical source simply acts as an electrical-to-optical transducer, therefore its non-linear characteristics (intermodulation, differential gain and phase) adversely affect the transmission quality in D-IM and AM-IM.

Commercially available LED sources driven by differential amplifiers allow studio quality only at low modulation indices, thus a reduced spacing is obtained as little signal power is available. For multichannel or repeatered systems, various techniques to reduce non-linearities were proposed, for example complementary distortion, in which compensating additional non-linear devices are employed; [17] negative feedback, in which a coupler-photodiode assembly is included in a control loop; feedforward, in which the error signal, obtained by the comparison of the signal before and after the distorting device, is combined beyond the circuit output. [18]

D-IM and AM-IM modulation of laser sources with wideband analog signals has been demonstrated with excellent results [19] but requires special devices.

The FM-IM and the pulse-analog techniques are very effective in reducing the influence of source non-linearities on transmission quality, at the expense of a higher signal bandwidth.

When pulse modulation is used, the drivers do not differ remarkably from those already described for digital signals. Linearity requirements completely lose their importance and an increased amount of power can be coupled into the fibre by driving the source at higher current levels. [20]

The receiver is designed to convert the incoming optical signal into electrical form and deliver it to the subsequent demodulator. Design criteria are therefore common to preamplifiers of digital systems. In this case, however, greater signal-to-noise ratios are required so that, in general, a repeater spacing inferior to a digital system with the same bandwidth is obtained.

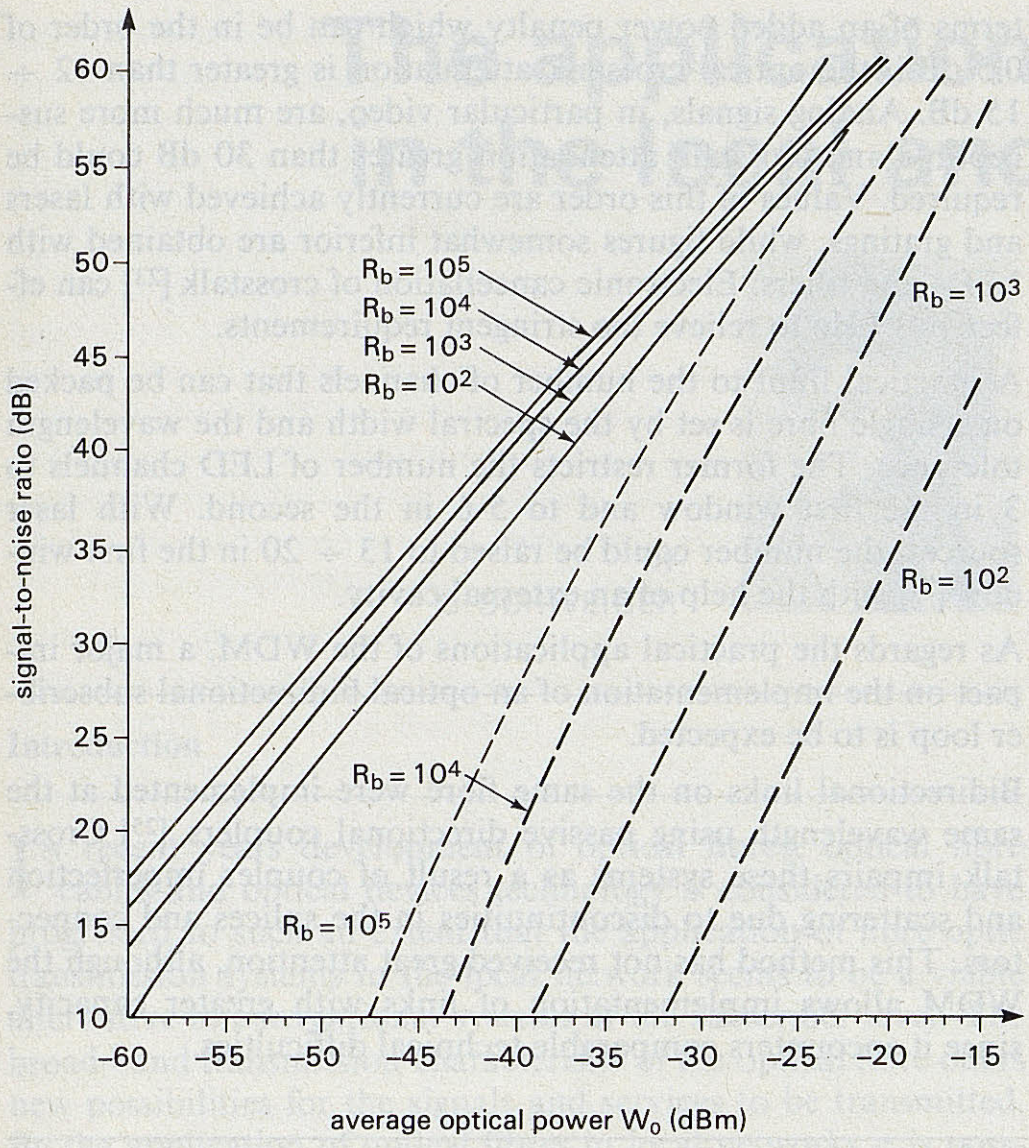


Figure 11 – SNR versus received average optical power for D-IM technique, m = *1 and different values of* R_b. *Solid lines refer to APD, dotted lines to PIN (first window detectors)*

3.3 System design

The structure of the transmission system and the evaluation of the signal-to-noise ratio (SNR) depend on the modulation technique adopted. As an example, only the D-IM technique is considered. For this technique the block diagram of the receiver can be assumed to be equal to that shown in figure 1 and the noise equivalent circuit for the preamplifier is the same as for figure 5.

With B_v denoting the information signal bandwidth, the SNR S at the receiver ouput is given, for a sinusoidal signal, by

$$S = \frac{(\rho\, G\, m\, W_0)^2}{4\left[\left(\frac{2\,K\theta}{R_b} + S_I + e\, I_d\, G_2 + e\,\rho\, W_0\, G_2\right)\int_0^{B_v} |H_a\, H_e|^2\, df + S_E \int_0^{B_v} |H_E|^2\, df\right]} \qquad (7)$$

where m is the modulation depth and W_0 is the average received optical power.

For PIN detectors, from *(7)* it is possible to deduce directly the average optical power required to obtain a given value of S.

In the case of APD, the SNR can be maximized, for a given W_0, through an appropriate choice of the avalanche gain G.

Numerical results refer to a first window system, to an information signal with 5 MHz bandwidth, and to receiver parameters adopted in section 2.6, with $I_d = 50$ pA.

Figure 11 reports the SNR (in dB) vesus W_0 (in dBm) for $m = 1$ and several values of $R_b = R_D \,//\, R_F$ both for APD (solid lines) with optimum gain and for PIN (dotted lines).

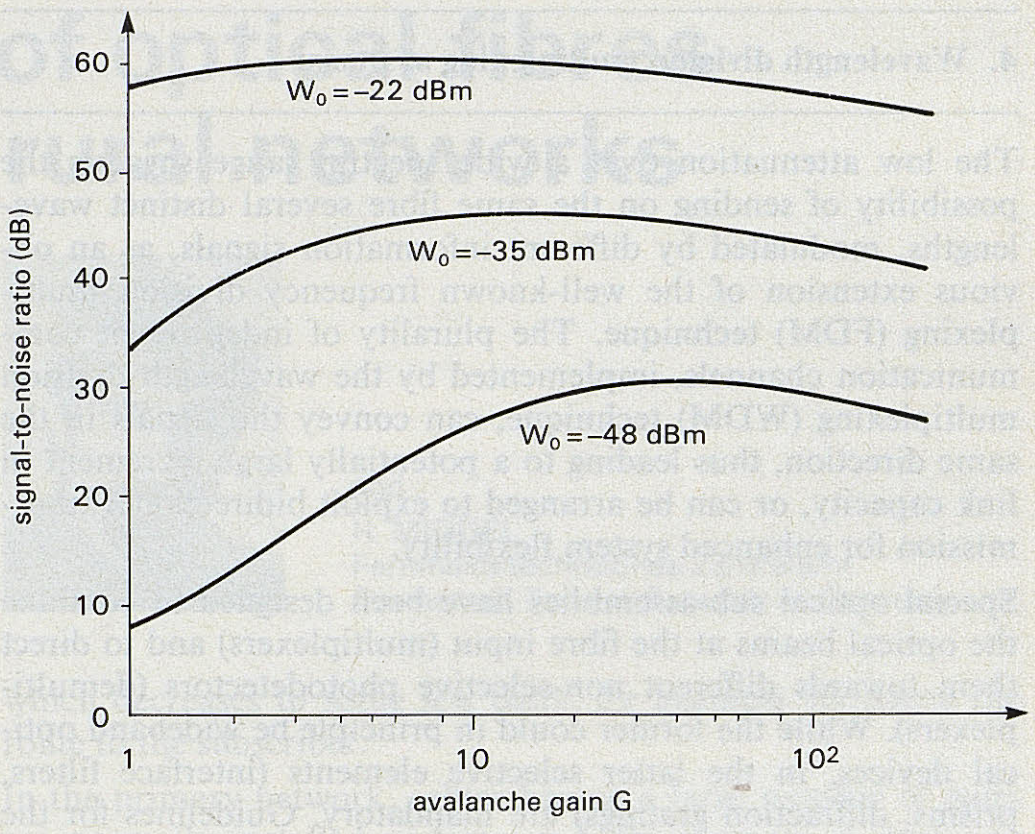


Figure 12 – SNR versus avalanche gain for D-IM technique, m = *1,* $R_b = 10^4\ \Omega$

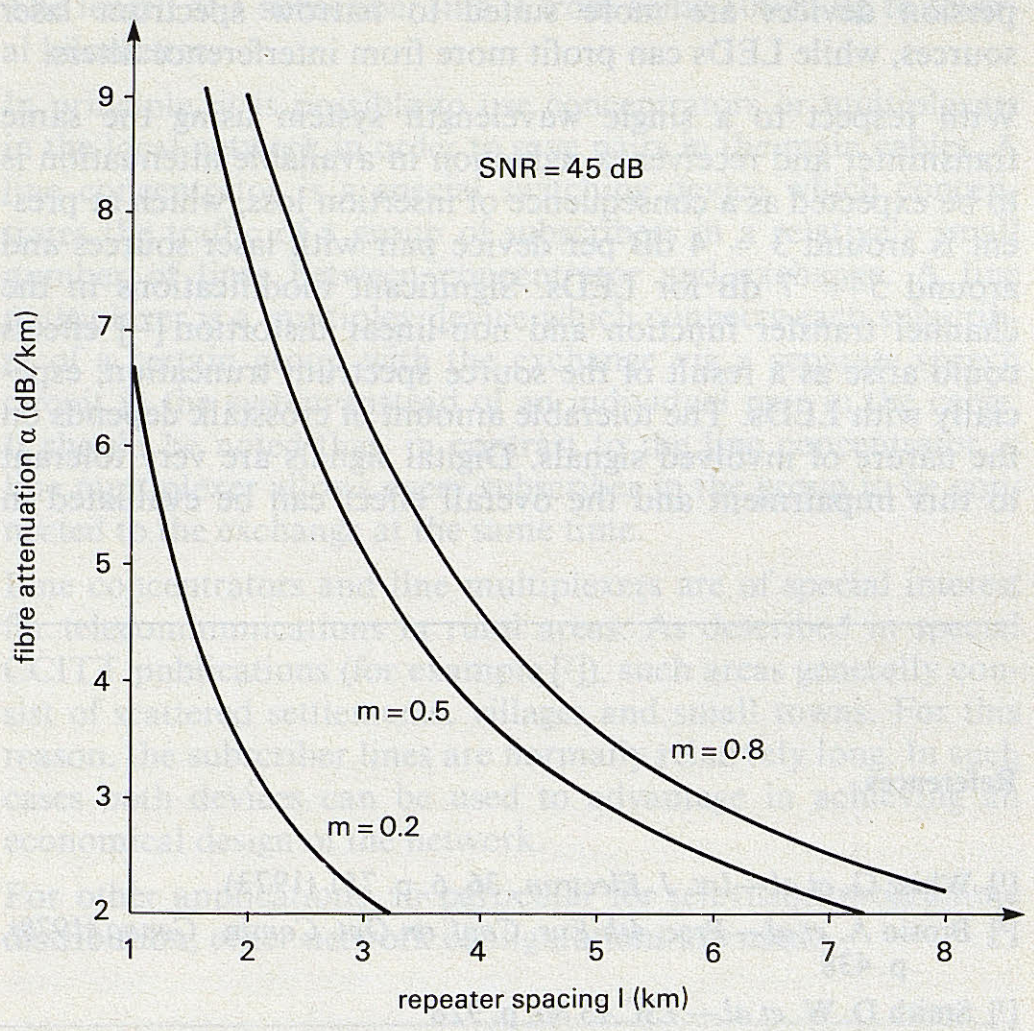


Figure 13 – Fibre attenuation versus repeater spacing

Figure 12 reports the SNR versus avalanche gain G for $m = 1$, $R_b = 10^4\ \Omega$ and for $W_0 = -22, -35, -48$ dBm; as can be noted, G is most effective in enhancing SNR when W_0 is small, while the advantages of avalanche multiplication are lost when W_0 approaches -22 dBm.

With reference to an LED source with an average optical power coupled into the fibre equal to -15 dBm, figure 13 shows the allowed fibre attenuation versus the repeater spacing for SNR = 45 dB and $m = 0.2, 0.5, 0.8$.

4. Wavelength division multiplexing systems

The low attenuation over a wide spectral range suggests the possibility of sending on the same fibre several distinct wavelengths, modulated by different information signals, as an obvious extension of the well-known frequency division multiplexing (FDM) technique. The plurality of independent communication channels, implemented by the wavelength division multiplexing (WDM) technique, can convey the signals in the same direction, thus leading to a potentially large increment in link capacity, or can be arranged to exploit bidirectional transmission for enhanced system flexibility.

Special optical sub-assemblies have been designed to combine the optical beams at the fibre input (multiplexers) and to direct them towards different non-selective photodetectors (demultiplexers). While the former could in principle be wideband optical devices, in the latter selective elements (interface filters, prisms, diffraction gratings) are mandatory. Guidelines for the design of such elements are to keep the insertion loss at the minimum, at the same time maximizing crosstalk attenuation taking into account the optical source characteristics and the number of required channels. Several papers have considered these problems in detail in connection with particular devices; a comprehensive review is reported in [21]. In general, angular dispersion devices are more suited to narrow spectrum laser sources, while LEDs can profit more from interference filters.

With respect to a single wavelength system using the same transmitter and receiver, a reduction in available attenuation is to be expected as a consequence of insertion loss, which at present is around 3 ÷ 4 dB per device pair with laser sources and around 5 ÷ 7 dB for LEDs. Significant modifications in the channel transfer function and non-linear distortion [22] effects could arise as a result of the source spectrum truncation, especially with LEDs. The tolerable amount of crosstalk depends on the nature of involved signals. Digital signals are very tolerant to this impairment and the overall effect can be evaluated in terms of an added power penalty which can be in the order of 0.5 dB if the optical crosstalk attenuation is greater than 12 ÷ 15 dB. Analog signals, in particular video, are much more susceptible and crosstalk attenuation greater than 30 dB could be required. Values of this order are currently achieved with lasers and gratings, while figures somewhat inferior are obtained with LEDs and filters. Electronic cancellation of crosstalk [23] can effectively help to relieve too stringent requirements.

A practical limit to the number of channels that can be packed on a single fibre is set by the spectral width and the wavelength tolerance. The former restricts the number of LED channels to 3 in the first window and to 5-6 in the second. With laser sources, the number could be raised to 13 ÷ 20 in the first window [24] with the help of an external cavity.

As regards the practical applications of the WDM, a major impact on the implementation of an optical bidirectional subscriber loop is to be expected.

Bidirectional links on the same fibre were implemented at the same wavelength using passive directional couplers. [25] Crosstalk impairs these systems as a result of coupler imperfection and scattering due to discontinuities in the splices and connectors. This method has not received great attention, although the WDM allows implementation of links with greater capacity, since it encounters comparable technical difficulties.

5. Conclusions

An outline of the problems involved in the design of transmission systems using optical fibres has been presented. System and circuit aspects have been analysed with particular emphasis on digital transmission systems as well as on an approach for the evaluation of repeater spacing. Finally, WDM systems, which could fully exploit the transmission capacity offered by the optical fibre, have been briefly examined.

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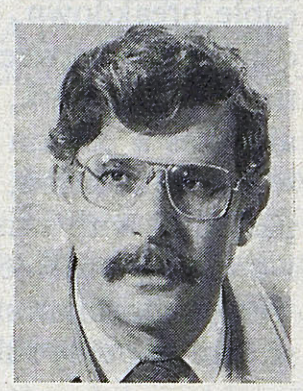
The application of optical fibres in the local and rural networks



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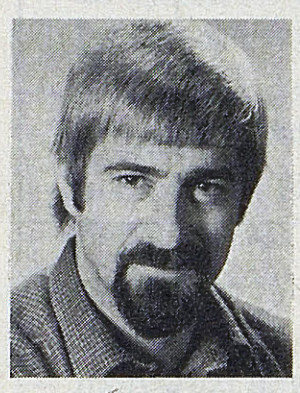


and
H. MIDDEL
Fernmeldetechnisches Zentralamt
Darmstadt, Federal Republic of Germany

Introduction

In recent years development of optical fibres, optical fibre cables and optical devices technology is considered to have progressed to such an extent that the application of fibre optic transmission systems in the local network seems to be a viable alternative to conventional systems at the subscriber level. The broad-band transmission characteristic of the optical fibre offers new possibilities for the signals and services to be transmitted. By the application of optical fibres in local networks it is possible to set up an integrated network providing narrow-band and broad-band services. Apart from increasing the quality and quantity of information, the installation of an optical fibre local network has enormous implications for fibre technology itself. The quantity of fibres required will enable the industry in future to produce a large amount of optical fibres and therefore to lower the price. As a result, an economic application of this new technology may become possible. It is also a well-known fact that the total cost of systems can be minimized by using an appropriate transmission method.

This article describes the optical fibre local and rural network, comparing it with the existing copper network, and derives from this the requirements for the cables and accessories to be used in this new network. A possible strategy for the introduction of this technology is outlined, taking into account the fact that the existing copper network will continue to be used as far as this is justified from the economic point of view.

Possible new services are described and the problems of maintenance are discussed.

1. Definition of the local and rural network

The local and rural network connects the subscriber with the local exchange (subscriber cables). [1] The networks can have various configurations—meshed, ring, tree or star. For telephone use, star configurations are at present predominant in local and rural networks. Such networks are built up in two steps, the primary and secondary network. This means:

— main cable (primary cable) from the distribution frame of the switching centre to the cabinet, and

— distribution cable (secondary cable) from the cabinet to the subscriber.

Normally, each subscriber is connected to the exchange by a separate circuit. As a result, the subscriber cables close to the exchange have a large number of pairs, for example 2000, which decreases to some few pairs, for example 10, along the route to the subscriber.

In the primary network, cables having a large number of pairs are normally installed underground, for example in ducts, or simply buried. In the secondary network, both underground and overhead installations (for example, figure of 8 cables) are used. If the cables are installed in ducts, manholes are provided at intervals. These manholes allow easy access to the cable network during installation and maintenance.

The length of a subscriber line is from some 100 m up to several kilometres.

In principle, it is possible to use concentrators or multiplexers in the local network in order to save pairs in the main cables. A line concentrator is a special switching device which concentrates the traffic of a group of subscribers in a relatively small number of lines between concentrator and exchange. A line multiplexer is a multiplex device which connects each subscriber of a certain group with the exchange via a separate speech circuit in the system instead of an individual pair in the cable. It should be noted that, in contrast to the line concentrator, a line multiplexer allows every subscriber in the group to be connected to the exchange at the same time.

Line concentrators and line multiplexers are of special interest for telecommunications in rural areas. As described in special CCITT publications (for example [2]), such areas generally consist of scattered settlements, villages and small towns. For this reason, the subscriber lines are normally relatively long. In such cases both devices can be used to advantage in achieving an economical design of the network.

For other applications, in particular for television programme distribution, other network configurations are used.

2. Configuration of a local and rural network

Depending on the services provided, the number of subscribers to be connected and their location, different configurations of the network are possible, for example, fully meshed, ring, tree and star (see figure 1).

In a meshed network, each subscriber is connected to every other subscriber by an individual line. This requires considerably more cable and manholes than any other configuration. No telephone exchange is required, however. Line utilization is very poor, and on the whole a meshed subscriber network is generally uneconomic and not used in practice.

In a ring network, all subscribers are connected by a single common line, like pearls on a string. Any information fed into the

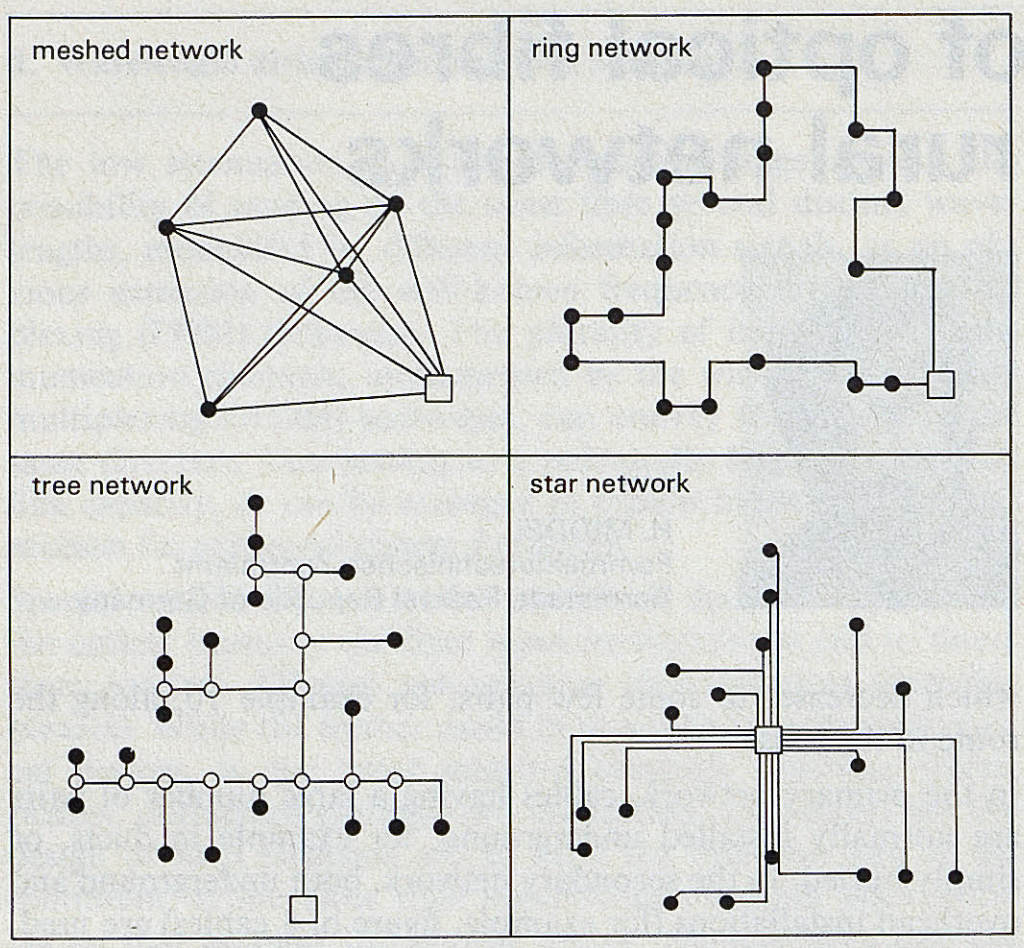


Figure 1—Network configurations

network by a subscriber passes through all nodes. For this reason a number of transmission channels have to be provided between all nodes, i.e. the terminals in the subscriber network, in line with the amount of traffic. A time division multiplex system in connection with a broad-band transmission medium is well suited for this purpose. At the nodes, only information addressed to a particular subscriber is taken from the network. Like the other network configurations, ring networks also need central devices, for example at a point where the information is handed over to the next heirarchical level. Furthermore, a ring network needs central control equipment to avoid blocking caused, for instance, by the repeated circulation of information with wrong addresses. In the case of the subscriber network, the transmission channels of a ring network are better utilized than in the meshed or the star, networks. On the other hand, there is a considerable disadvantage because of the vulnerability of the single-way ring network, which is affected by failures in the complex technical equipment of the subscriber stations and by cable breakdowns. The measures needed for improving reliability, a two-way ring network, for example, would make this network less economic. Moreover, ring networks are not compatible with the existing networks and need transition devices with stores and signal converters at the connection points. The enlargement of the ring network is limited by the bandwidth of the transmission medium used for the ring, taking into account the bandwidth needed for each individual subscriber.

The tree network consists of several branches, which in the case of a network for two-way communication comprise two paths with opposite transmission directions. Both paths contain the same number of transmission channels. Each subscriber is connected to both paths for sending and receiving. For the exchange of information in the network it is essential to connect the lines at the branching points in such a way that on the receiving line of all branches the information fed into the network can reach all subscribers. Furthermore, it is necessary to connect the paths for both directions at the end of each branch so that information feedback is possible. Comparing tree with ring networks, it can be stated that the former is more flexible with regard to topographical enlargement. However, for both types of network the number of subscribers is limited by the transmission capacity of the lines used. An enlargement by a second line results in doubling of the equipment spread over the network. Only a part of a tree network can be put out of operation by a cable breakdown. But the consequences are more severe if the connection between two branching points is interrupted. As in the ring network, the reliability of the subscriber equipment also has a certain influence on the total reliability of the network. In addition, it should be mentioned that there is no compatibility with existing telecommunication networks. Tree networks are considered advantageous for distribution purposes, where information is distributed from a central source downstream to many subscribers (for example cable television).

In a star network each subscriber is connected to the telephone exchange by an individual connection. Compared to a ring or tree network, a considerably increased amount of cable is required and it will need more cable lines than a ring network. These disadvantages are partially alleviated by the fact that, in contrast to other network configurations, many of the essential characteristics such as reliability, availability, etc., are mainly determined by the telephone exchange. In the subscriber area, one line for both transmission directions without any multiplex equipment is sufficient as a rule. The bandwidth needed for this line is comparatively small because it is determined by the transmission bandwidth used by one individual subscriber and not by the sum of the bandwidths of the transmitted signals of all subscribers, as is the case in other networks.

The star network is relatively insensitive to cable breakdown because only those subscribers who have their lines in the damaged cable are affected, and not all subscribers as is the case in a single-way ring network.

In addition, the star network offers a high degree of security against interception and good conditions for maintenance. Network expansion is also easy to achieve. Finally, the subscriber equipment is considerably less complex and cheaper than that for networks without a central telephone exchange because there is no need for control, switching and monitoring devices. For this reason, two-way communication networks, and in particular all telephone networks, almost invariably use the star configuration.

3. Optical fibre local and rural networks

In view of the definitions given above and the alternative network configurations the question arises as to which configuration is appropriate for the introduction of optical fibres into local networks. The following reasons make the star configuration appear to be the ideal structure for this purpose.

As has been outlined above, star networks use a larger quantity of cable than tree or ring systems, however, investigations into the cost structure of local networks have shown that cable accounts for only a small fraction of the total cost. This tendency is emphasized when the expected decrease of optical fibre prices caused by ever-larger production has reached a point where the price of copper pairs is approached.

An optical fibre network with star configuration leads to a network which will allow two-way transmission of all existing narrow-band and broad-band services, incuding all services foreseen in the future on a single subscriber line. In this manner an integrated broad-band telecommunication network can be set up. Such a network will open the way for the introduction of

new two-way broad-band services, and in particular videophone conversations and conferences.

The higher cost of optical fibre cables is certainly more than compensated by the savings in civil engineering costs which would result if the existing telephone networks using copper pairs were supplemented by a broad-band CATV network and, at later date, by another broad-band telecommunication network.

The infrastructure of the existing copper star network also seems to be suitable for optical fibre systems. Therefore, a completely new network system with new cable ducts, a new routing of buried cables and new local sites for exchange offices, concentrators and multiplexers will not be necessary.

Where an integrated network (with bidirectional broad-band services) is not planned, configurations other than a star network could be envisaged. This could be a possible solution as regards the introduction of optical fibres in the rural network if only broad-band distribution services (CATV, etc.) are to be provided. It is clear that for the fibres used in this network different properties with respect to attenuation, bandwidth and wavelength will be required, depending on the distance of the customers from the exchange, the kind of services transmitted and the transmission procedure selected.

Besides the graded-index fibre 50/125 µm recommended by the CCITT (Recommendation G.651) it may be possible to use other types of fibres such as step-index or single-mode optical fibres. Depending on the distance between the subscriber and the local exchange, the use of different types of fibres with different attenuation and bandwidth values could be suitable for reasons of economy (e. g. to avoid repeaters).

The power supply for the subscriber equipment is of great importance if the copper network is generally to be replaced by an optical fibre network for the transmission of all services. The following solutions seem to be practicable:

— local feeding of the subscriber terminal by connection to the public power supply with or without battery;

— use of other energy sources (generators, solar panels, etc.).

These concepts are new as far as maintenance facilities are concerned, but the required equipment is available.

In the optical fibre network, power feeding of the subscriber terminals by existing copper cables or copper wires inside the optical fibre cables will not be appropriate since the remote power feeding of the subscriber terminals would be a special planning task of great importance entailing the provision of large quantities of copper.

For this reason the optical fibre star network could be built up using cables without any metal. The power supply for the subscriber equipment will be decentralized. If concentrators and/or multiplexers are used, for example in the rural network, the power feeding of these devices has to be considered as a special task. A possible version for the configuration of a local network with fibre optic cables is shown in figure 2. [3]

4. Transmission methods

The choice of the transmission system to be used depends on the services to be provided such as picture telephony, colour television, video conferences and narrow-band inegrated services. [3-7]

The design of an integrated wide-band telecommunication subscriber network should be based on the following fundamental requirements:

— one fibre for each subscriber;

— an option for the use of several wavelengths (WDM), as a future possibility;

— a modular system configuration for system installation depending on subscriber requirements;

— full compatibility with the existing service networks (telephony, data);

— compatibility—if possible—with the existing subscriber equipment;

— individual power supply for subscriber equipment;

— minimum service in the event of an electrical power breakdown (e.g. telephone).

The following transmission methods on optical fibres can be used to meet the above-mentioned requirements:

— analogue systems:
  — wavelength multiplex (direction separation by optical couplers),
  — space multiplex;

— digital systems:
  — wavelength multiplex (direction separation by optical couplers),
  — time division multiplex,
  — space multiplex.

Which transmission system is best suited for a particular network configuration has to be determined by a cost-benefit analysis. The optical fibres and the cable types will then be chosen accordingly.

5. General requirements to be met by optical fibre cables and accessories

As shown above, the star network has for many reasons the most advantages. It is therefore necessary to know the general requirements to be met by optical fibre cables, their accessories and their installation, which result in particular from the conditions imposed by the structure of the network.

The optical fibre cables to be installed in local networks should not only have specific transmission properties but must also meet the requirements which result from rough environmental conditions in the local network. This means that the pulling and laying behaviour of optical fibre cables must at least equal that of copper cables.

The planning of the network also has to take into account existing ducts, manholes, etc. For instance the maximum outside diameter of the cable should not exceed 85 mm in the case of ducts with an inner diameter of 100 mm.

5.1 Cable construction

The local network comprises cables ranging from those with a few fibres (2 to 100) for distribution to large-capacity fibre cables with 100 to 4000 optical fibres. To minimize the variety of cables it is necessary to build them up on a uniform pattern.

The cable construction mentioned below represents only one of several possibilities. The types of cables hitherto known such as ribbon or V-grooved are described. [8]

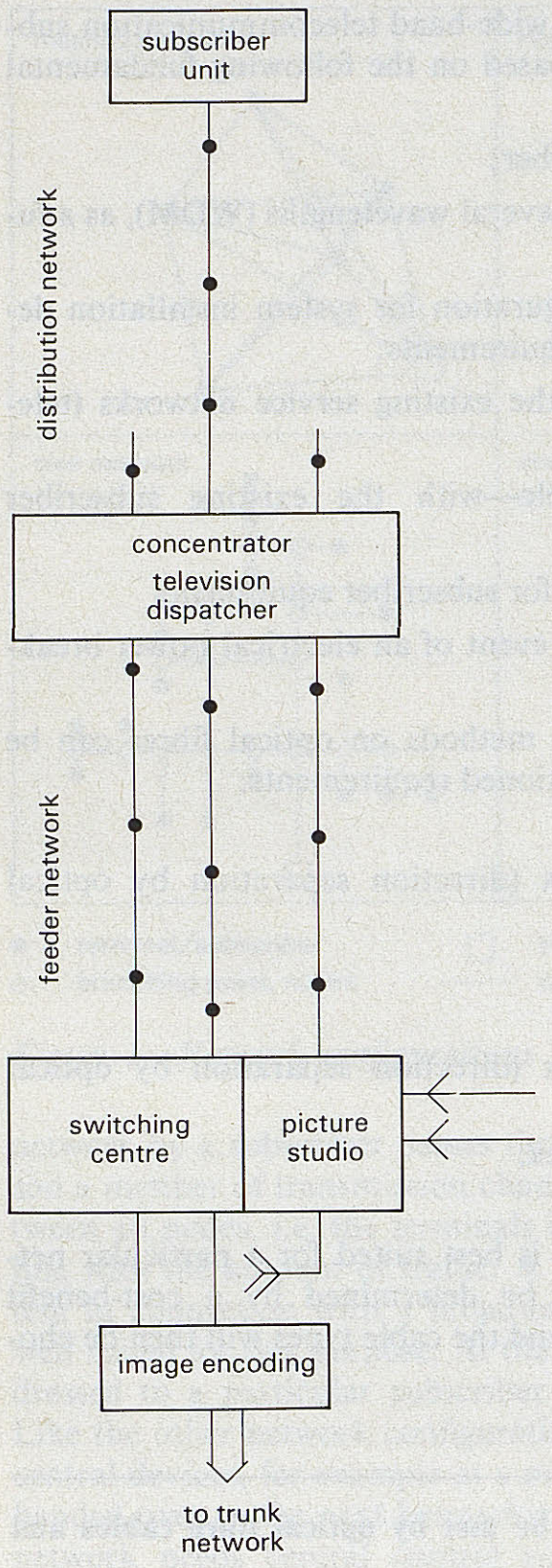
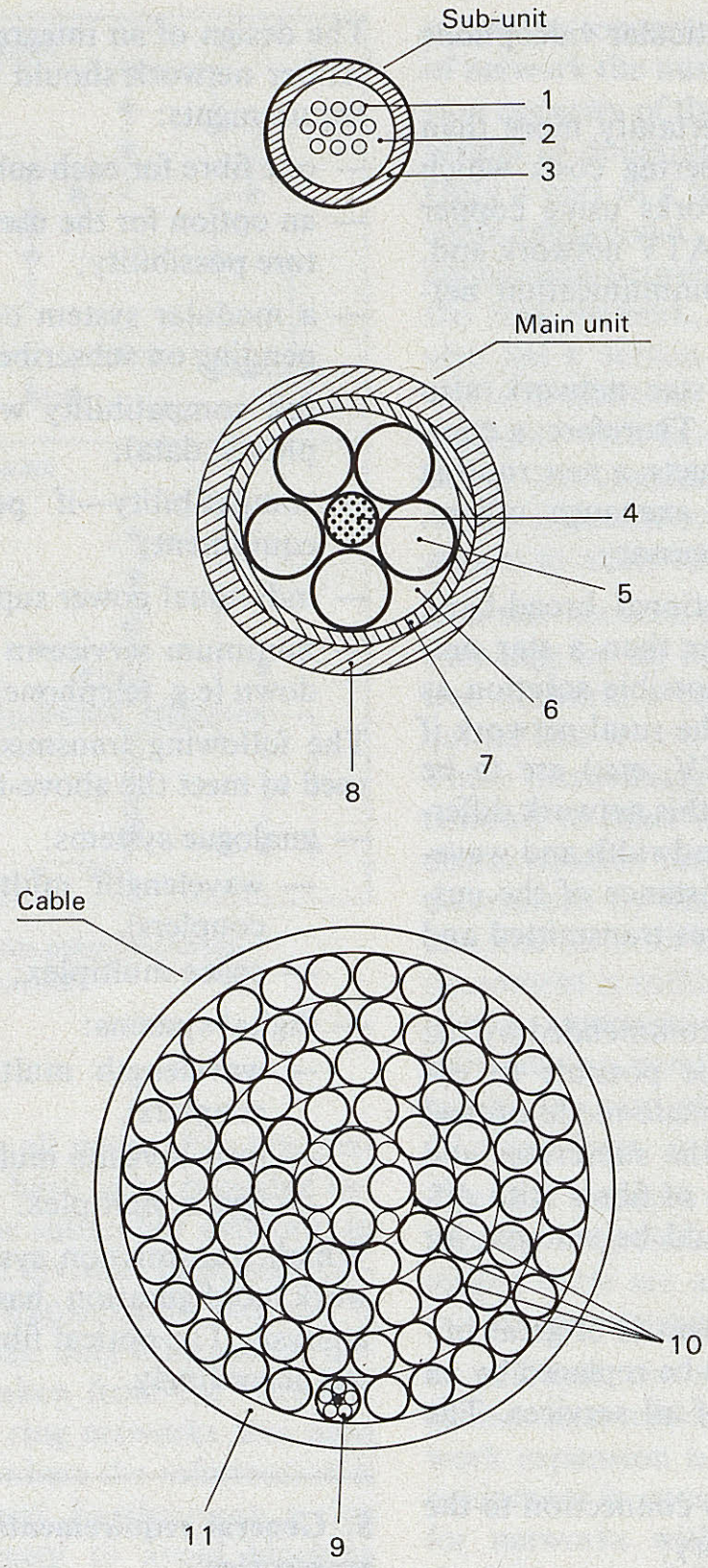


Figure 2—Local network



1 = *optical fibre*
2 = *filling compound*
3 = *buffer*
4 = *central member*
5 = *sub-unit with 10 optical fibres*
6 = *filling compound*
7 = *inner jacket*
8 = *outer jacket*
9 = *main unit with 5 sub-units*
10 = *tape ring*
11 = *sheath*

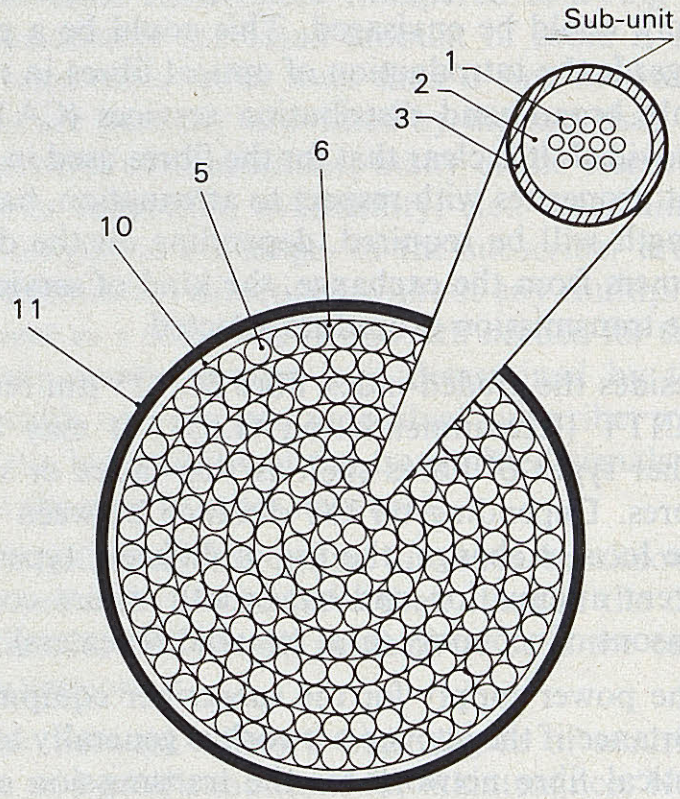


Figure 3—Make-up of cables with a large number of fibres for the local network

A cable design aiming at a sub-unit with 10 fibres, for example, appears to be suitable. To keep the diameter of the sub-unit small, the fibres will be laid together in a loose buffer (see figure 3).

This sub-unit with a loose buffer permits the free movement of the fibres in the same way as the loose buffer of single fibres at a considerably higher packaging density. A further advantage of this element is easy adaptation to the number of fibres needed. It can be filled longitudinally so as to be waterproof, and the mechanical characteristics of the cable can easily be adapted to this application.

The make-up of large-capacity fibre cables with a large number of fibres can be achieved, as is shown in figure 3, by layer-stranding of sub-units or by unit-stranding of, for instance, 5 sub-units to form a main unit. [9-12]

As regards the filling, the cable core can be filled in the usual way with the compounds commonly used in traditional cable engineering, for example petrolatum.

With this sub-unit it is easy to provide the form of aerial cables, which are frequently used, especially in the rural network. The suspension strand is brought up to the core asymmetrically in the shape of an 8 or concentrically.

This unit-type cable core allows the use of jacket constructions and materials already known in these networks.

Because the fibre attenuation is low, regenerators are generally not required in this network. Only in the case of rural networks may concentrators and multiplexers be necessary. This means that, for power feeding, copper wires would be required. With this cable design it would be appropriate to have a separate power cable and not to include copper wires in the fibre cable. This would decrease the number of cable types and simplify the measures to be taken for the safety of personnel.

5.2 Joints and accessories

The connection and distribution housings used in the optical fibre local network have to be in accordance with the requirements of optical fibre cables. This means additional fibre length for the splices, space for splices storage, and connection of the reinforcement elements. It is necessary to ensure that the housings can be re-entered easily.

Before considering the general principles, one point has to be mentioned especially: if a uniform connection technique (splices, connectors) is to be used in the local network, which is a very restrictive requirement, one has to make sure that fibres

produced by different processes for use in the same local network are compatible as regards splices and connectors.

Any plan for splicing techniques in the local network has to consider that:

— the splicing time must be minimized;

— the sub-units have to be connected and stored in units;

— execution of a branch-off must be easily possible;

— the splices must be easily accessible;

— additional fibre length for further splices must be available.

As in the conventional copper cable technique, optical splices must also be accommodated in housings. But the inside make-up of these housings must be designed for installation with optical fibres. Here a magazine system with 10 splices, for example, is possible (see figure 4).

Distribution points might be desirable for reasons of economy with a view to expansion and flexibility of the secondary network to the subscriber, as is usual in the existing copper network. However, when a decision is taken on the need for such distribution points, the special conditions of optical fibre cables (e.g. additional loss) have to be taken into account.

It is necessary to develop adequate terminals in exchanges and at subscriber stations with the possibility of installing test and measuring points. But their installation is limited by the fact that additional loss will reduce system length.

In the construction of the active elements in the link (concentrators, multiplexers), requirements such as easy handling of the elements, space requirements, power feeding, heat exchange and the safety of personnel have to be taken into account.

The number of connectors has to be reduced to a minimum where the connector loss exceeds the loss of a splice and no sufficient attenuation reserve is available. In any case the connector construction (prefabricated or field-installed) has to be adequate for the environmental conditions.

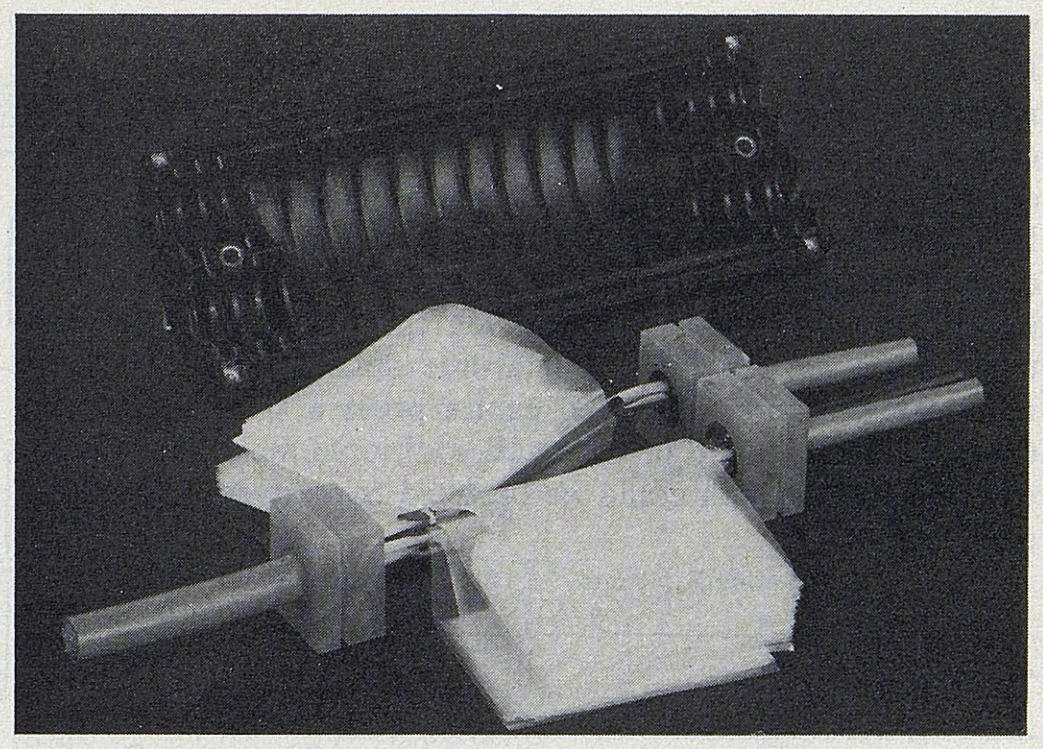


Figure 4—Design for housings with a magazine system for containing the 10 splices of a sub-unit using plastic envelopes (above) or boxes (below)

6. Installation

Before the installation of optical fibre systems in local networks can start it is necessary to find out whether the existing link equipment (ducts, manholes, distribution points) can be used or whether it can be adjusted to the requirements of the optical fibre cables. A solution to the problem of multiple use of exisiting cable ducts is shown in figure 5.

The decision as to whether the optical fibre cables are to be buried or installed as aerial cables depends on the particular situation of the link. An important installation work may have to be done.

Special problems could arise in connection with the installation of indoor cables to the subscriber, especially if the installation tubes have reached their maximum capacity. In that case, a great deal of new installation work may be necessary.

In principle, the laying and installation of optical fibre cables should not require any additional measures over and above those required for copper cables. Their lower weight may even lead to advantages in cable laying. Furthermore, this lower weight permits longer laying lengths, which help to reduce the number of splices and also of manholes. To take advantage of this, additional measures such as interstitial pulling and special preparation of the cable ends for the pulling process may be required. For housing and splicing, easy handling techniques,

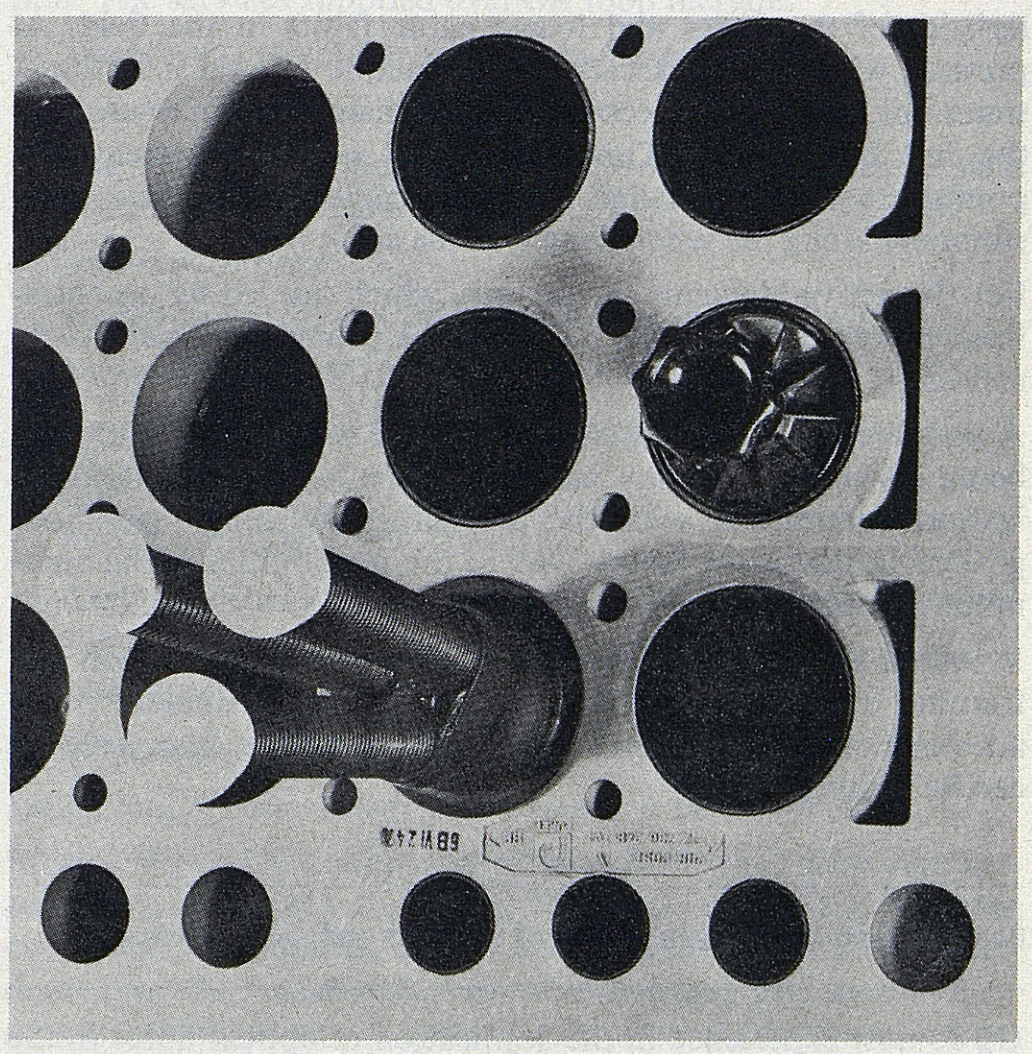


Figure 5—Dividing ducts with, for example, 3 plastic tubes

which can be done by the existing crews, must be developed. For example, the splicing time required for cables with a large number of fibres is at present too long because of the time-consuming single fusion splicing technique. It is necessary to develop automatic splicing techniques for optical fibre cables. In choosing the right splicing techniques it is important to reduce the required correlation between splicing time and splicing loss. This could mean that epoxide splices are more suitable than fusion splices. When metal-free optical fibre cables are used, the detection of buried cables poses a special problem. One possibility would be to install additional metallized plastic warning tapes which could be detected by conventional metal detectors.

7. Maintenance

As regards the maintenance of an optical fibre local and rural network, the problems encountered will be the same as those already known from the existing network.

Like the existing copper cables, optical fibre cables have to be protected, monitored and, if necessary, repaired. Cables which are not protected against moisture penetration by a filling compound can be monitored and protected by pressurization.

In addition, some new problems arise from the nature of the optical fibre itself. Every splice increases the attenuation in an optical link. It is therefore necessary to take into account that the additional attenuation in the system is entailed by repairs and diversion laying, which requires additional splices and a longer cable length. This means that, when maintenance work such as changing faulty cable pieces and splicing in additional lengths is carried out, care has to be taken not to exceed the allowed overall attenuation. In some cases it will be necessary to replace some shorter pieces of cable by one longer single cable length to reduce the splices, or to install a new cable with lower attenuation per kilometre.

Measurement techniques for optical fibres require new measurement devices. It is necessary to measure the optical characteristics of the fibres and locate cable faults in the field. At present, when the backscattering technique is used it is sometimes not possible, on account of the dynamic range, to monitor the full link length. This means that additional measuring points have to be installed along the cable line to allow measurement along the whole length of the cable link.

For the active elements in the link, which are fed by decentralized power supply units, maintenance problems remain to be solved.

A possible risk of eye injuries due to the use of laser sources is being discussed by many national and international standardization committees with the aim of establishing regulations governing the use of lasers. One of the possibilities is the automatic switch-off of the laser in the event of a cable breakdown.

Provided that due consideration is given to the instruction and training of maintenance staff and to the establishment of an adequate organization, maintenance of the optical fibre network can be ensured.

8. Practical experience gathered in local and rural networks

Up to now experience in the application of optical fibres in the local and rural network has been limited to small-scale trials where copper wires have been replaced by optical fibres. The services transmitted remain unchanged. In some field trials which are being conducted in local and rural networks optical fibres are used for the distribution of television programmes in connection with a return channel for programme selection. The networks used are star networks.

Field trials with optical fibres at this network hierarchy level are planned for the near future, their aim being the transmission and exchange of integrated broad-band services through analogue and digital signals. Some of these field trials do not only cover a technological examination of the individual components such as cables, housings, concentrators and multiplexers and of the network structure chosen but are also intended to check the social relevance and acceptance of the extensive new services.

We give below some data on different field trials which are already being conducted or are planned in the near future:

8.1 In France: the Biarritz project

In September 1979, the French Administration decided to implement an optical network in Biarritz.

This trial is being conducted with a view to a future integrated multi-service network.

Biarritz is a seaside resort with 28 000 inhabitants on the Atlantic coast near the border with Spain. Two areas of the town have been chosen for testing a new CATV system which improves reception and offers extra services: telephone, picturephone. The following particulars are given:

- *Services:*
  - picturephone;
  - distributed services including television and hifi audio channels; 2 television programmes and 1 hifi stereo programme can be chosen from 15 television programmes and 12 stereo FM channels;
  - telephone.
- *System parameters:*
  - star network;
  - maximum cable length: 1675 m (mean length: 795 m);
  - a connector at both ends (maximum loss: 1 dB/connector);
  - a splice every 600 m (maximum loss: 0.5 dB/splice);
  - attenuation for the cable: 4.5 dB/km;
  - 5 dB margin for repairs and system reserve;
  - combined analogue (television) and digital (telephone) transmission;
  - central units for switching and control of the exchange and for the distribution of programmes by transmission to the subscriber connection unit;
  - subscriber connection unit for connection of the subscriber, concentration of telephone and picturephone traffic, and selection of distributed programmes and command by the subscriber.

The system will be in operation in 1983.

8.2 In Japan: the Yokosuka field trial

The main aim of the Yokosuka field trial has been to develop a "business-use" subscriber loop system, which is intended to carry television conferences, multiplexed PBX signals, high-speed data signals and so on. In addition to the "business-use" system, a "home-use" subscriber loop system and a CATV distribution system are also being tested. The "home-use" system

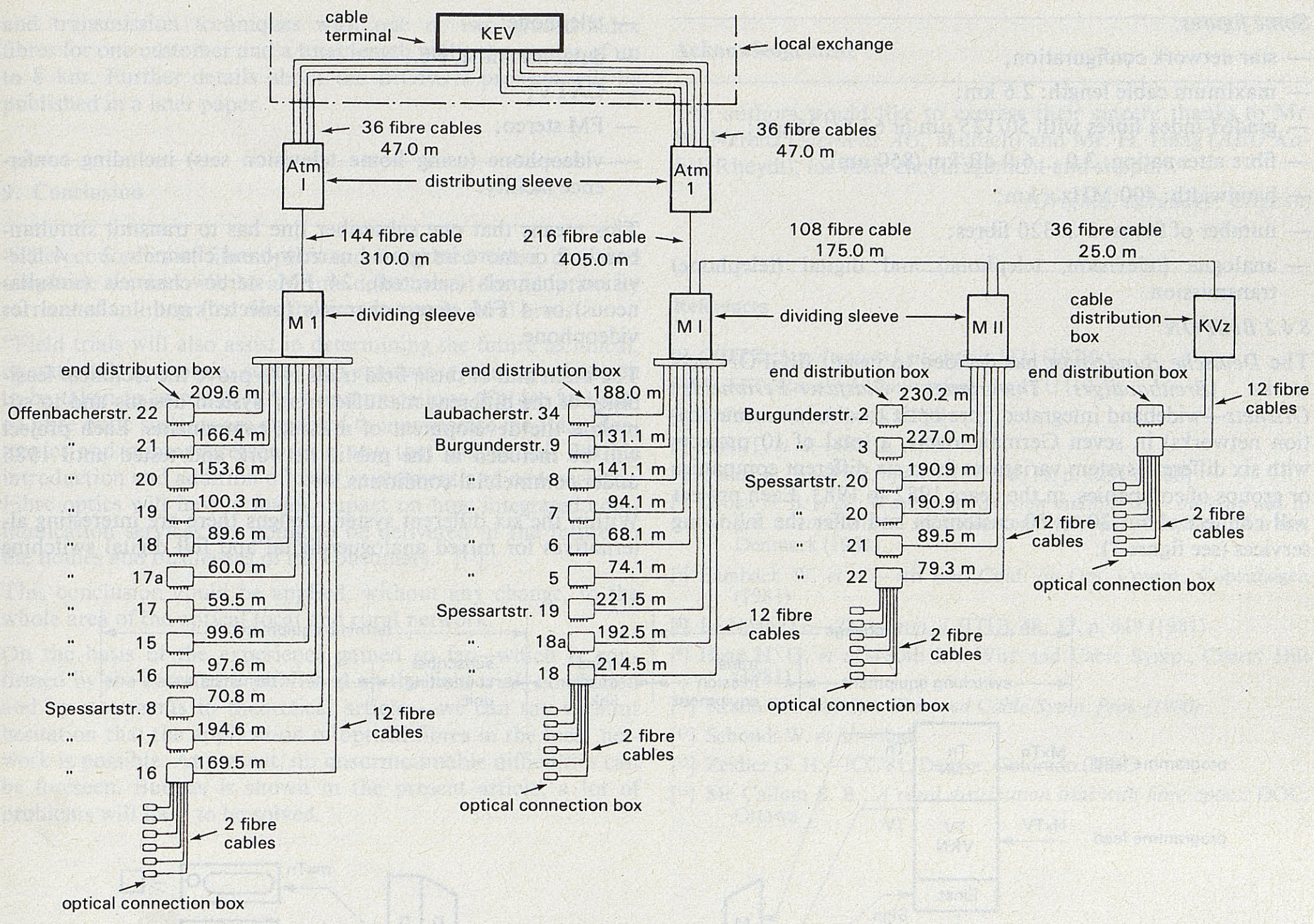


Figure 6—Layout of a complete network for 150 subscribers (example)

provides end-to-end or centre-to-end video service as well as conventional telephone services.

Some details of the Yokosuka field trial:

- *System configuration:*

— star network;

— graded-index fibre: 3dB/km (0.85 μm), 1.2 dB/km (1.3 μm);

— bandwidth: 400 MHz × km;

— cable length: 8.5 km;

— number of fibres: 10;

— services: telephone, high-speed facsimile, and data, television, high definition television, very high frequency television;

— wavelength: 0.8-1.3 μm (WDM).

8.3 In Canada: the Elie rural field trial

- *System description—services:*

A total of 150 subscribers will be served by this field trial. Approximately 70% of the selected trial participants are located in communities and the rest are dispersed over adjacent rural areas. The subscribers will be served over fibre optic loop circuits which emanate in a star configuration from two distribution centres, the Field Trial Centre (FTC) in Elie and the Remote Distribution Centre (RDC) near St. Eustache. These distribution centres are housed in trailers and are interconnected by a non-repeated 9 km fibre trunk cable carrying digital and analogue signals. The longest subscriber fibre loop circuit wil be 5 km, carrying the integrated loop signal to the subscriber location. The services supplied over the loop include:

— single party telephone with up to 4 extensions;

— choice of 7 stereo FM channels, and

— one full duplex 56 kbit/s synchronous transparent data channel to each subscriber for additional digital services.

- *System parameters:*

— graded-index fibre: 4 dB/km (840 nm and 930 nm);

— bandwidth: 400 MHz (trunk), 600 MHz (loop);

— trunk length: 9 km (without repeater);

— total loop length: 75 km;

— maximum loop length: 5 km;

— digital (DS1, DS2) and analogue (television, etc.) transmission;

— 160 subscribers.

8.4 In Germany

8.4.1 Optical cable subscriber network in Berlin (West)

From 1979 to 1980 three commercial field trials were conducted, which connected about 350 telephone subscribers with the exchange (see figure 6), and 1 commercial field trial was conducted for the transmission of television and FM stereo channels to 24 subscribers (2 from 12 television channels and 2 from 24 FM stereo channels).

Some figures:

— star network configuration;
— maximum cable length: 2.6 km;
— graded-index fibres with 50/125 µm or 62.5/125 µm;
— fibre attenuation: 3.0 ... 6.0 dB/km (850 nm);
— bandwidth: 400 MHz × km;
— number of fibres: 2 ... 320 fibres;
— analogue (television, telephone) and digital (telephone) transmission.

8.4.2 BIGFON

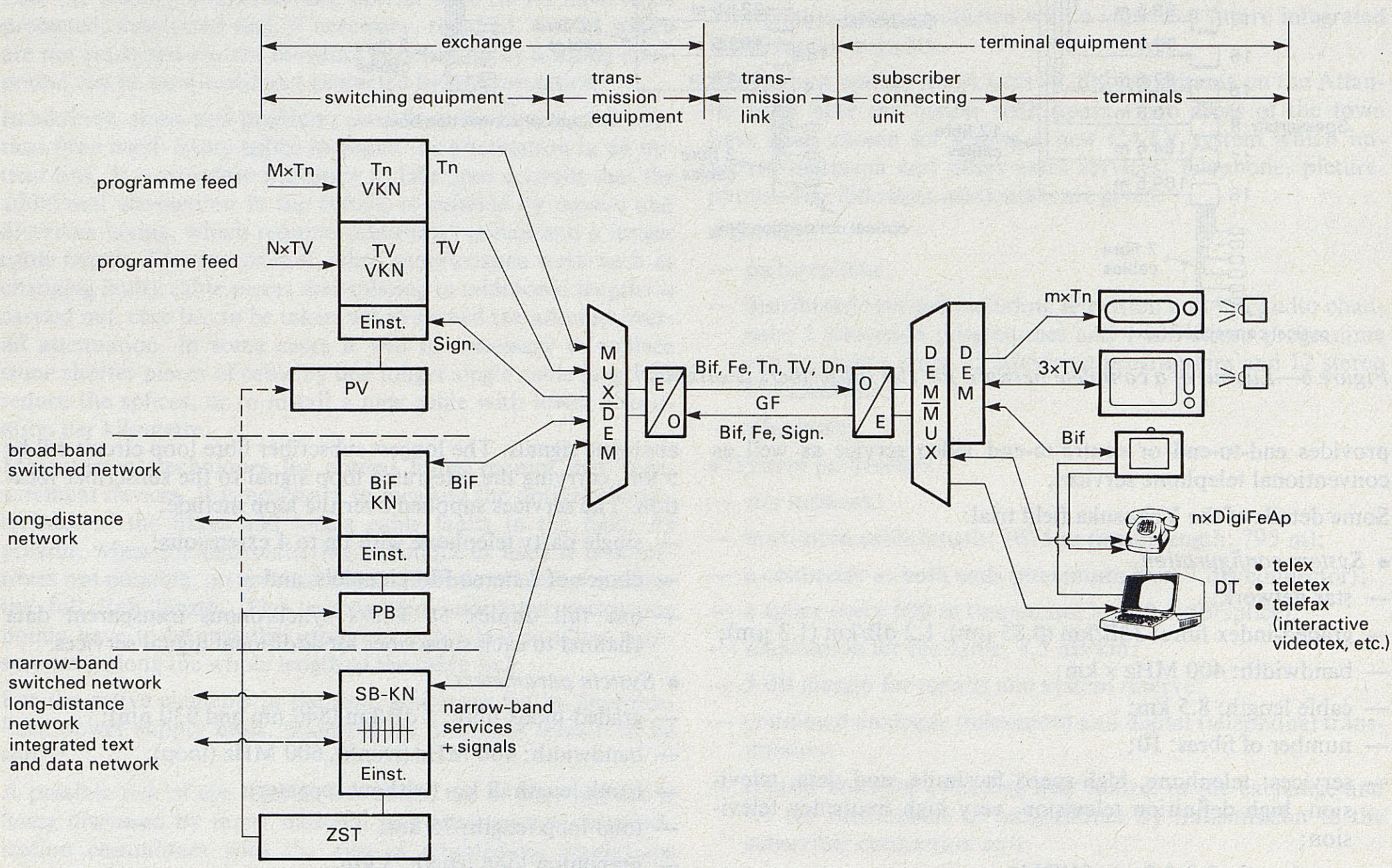
The *Deutsche Bundespost* has decided to install BIGFON networks (*Breitbandiges Integriertes Glasfaser-Fernmelde-Ortsnetz*—wideband integrated fibre optic local telecommunication networks) in seven German towns, a total of 10 projects with six different system variations from six different companies or groups of companies, in the years 1982 to 1983. Each project will connect about 30 to 50 customers and offer the following services (see figure 7):

— telephone;
— data, facsimile, etc.;
— CATV;
— FM stereo;
— videophone (using home television sets) including conference facility.

This means that one subscriber line has to transmit simultaneously 2 or more integrated narrow-band channels, 2 ... 4 television channels (selected), 24 FM stereo channels (simultaneous) or 4 FM stereo channels (selected) and 1 channel for videophone.

The main aim of these field trials is to prove the technical feasibility of the different manufacturers' system designs and to stimulate the development of missing components. Each project will be included in the public network and tested until 1986 under commercial conditions.

Within the six different system designs there are interesting alternatives for mixed analogue/digital and full digital switching



Dn = *data*
Fe = *telephony*
TV = *television*
Tn = *sound*
Tn-VKN = *switching matrix for sound programme distribution*
TV-VKN = *switching matrix for television programme distribution*
GH = *optical fibre*
BiF = *picture telephony*
PV = *processor for broad-band switching matrix for programme distribution*
PB = *processor for BiF-KN*
ZST = *central control*
DT = *data terminal*
SB-KN = *narrow-band switching matrix*
DigiFeAp = *digital telephone apparatus*
BiF-KN = *switching matrix for picture telephony*
Einst. = *controller*
Sign. = *signals*

Figure 7—Possible system for a broad-band integrated local telecommunication network

and transmission techniques with one or two graded-index fibres for one customer and a total length without repeater of up to 8 km. Further details about the BIGFON projects will be published in a later paper.

9. Conclusion

"The economics of fibre optics and integrated video, data and telephone services will be a prime determinant for adoption by carriers of an integrated distribution system in rural areas.

"Field trials will also assist in determining the future technical, operational, economic, social and regulatory courses of action to be taken to improve rural communications. Future integrated fibre optic systems are expected to incorporate modular electronics and microprocessors in a way that will permit flexible introduction and addition of plant investment and new services. Fibre optics will have a major impact on how integrated communication services are going to be delivered in the future to the homes and businesses of the consumers." [13]

This conclusion could be applied, without any change, to the whole area of the optical local and rural network.

On the basis of the experience gained so far—which is confirmed by the comments published on the field trials conducted and by statements in theoretical articles—we can say without hesitation that the application of optical fibres in the local network is possible. At present, no unsurmountable difficulties can be foreseen. But, as is shown in the present article, a lot of problems will have to be solved.

Acknowledgement

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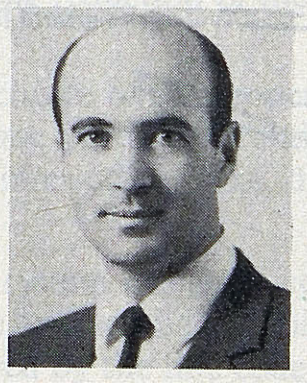
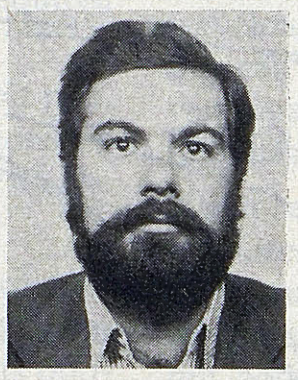
The application of optical fibres in the junction network

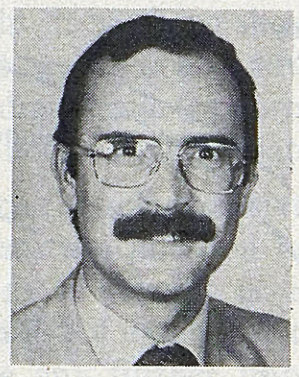
by

O. COTTATELLUCCI

Istituto Superiore delle Poste
e delle Telecomunicazioni (ISPT)
Rome







F. LOMBARDI

Società Italiana per
l'Esercizio telefonico p.a. (SIP)
Rome

and

G. PELLEGRINI

Centro Studi e Laboratori
Telecomunicazioni (CSELT)
Turin
Italy

1. Introduction

ADVANTAGES of optical fibres, such as low transmission loss, wide bandwidth, insensitivity to electromagnetic interference, small bending radius, have been listed and emphasized many times, since their appearance, as a suitable transmission medium. In addition, the large variety of applications of optical fibres in the telecommuniction network—from local loop to submarine links—confirms the validity of adopting this new carrier as transmission medium.

Referring, in particular, to junction network applications, all the above-mentioned features make optical fibre transmission systems especially suitable; as an example, low losses allow central offices to be linked without intermediate repeaters, and the small size of optical cables permits a more efficient utilization of ducts, thus resulting in noticeable cost savings.

Several aspects which are of general relevance to optical fibre systems (e.g. design considerations, link attenuation, spreads due to optical fibre classification, effects of modal noise on system performance) are not dealt with in this paper, as more extended analyses are performed in relevant papers elsewhere.

Here the application of optical fibres in the junction network is examined in some detail, in order to assess the merits of this rather new technique with respect to the specific characteristics of this area of the telecommunication network. In Section 2 the characteristics of the junction network are reviewed, with reference to particular national conditions. Section 3 is devoted to the analysis of transmission systems that seem most suitable for use in the junction network. Section 4 is concerned with the features of optical fibres, taking into account the characteristics of both the junction network and the system envisaged. Then, considerations are developed in Section 5 about cable characteristics and laying, that are particularly affected by the junction network features. Section 6 reports analyses of maintenance philosophy that is particularly suited for systems and links foreseen in this area. Finally, Section 7 gives an account of some practical experiences, already developed, that can be considered as significant examples of the use of optical fibre transmission systems in the junction network.

2. Characteristics of the junction network

The main characteristics of the junction network in different countries are reviewed in this section. First of all, it must be noted that it is not possible to give a general indication for the distribution of distances between switching stations in the junction network of large urban areas, as this part of the telecommunication network has characteristics which are very different for the various countries.

Examples of distributions of inter-office span lengths are shown in figure 1.

The United States distribution refers to the T1 (1544 kbit/s) system span lengths of seven metropolitan areas. As it can be seen from the inspection of figure 1, about 30% of the spans are shorter than 6.4 km, while abut 80% are shorter than 12.8 km.

There is a very similar distribution in two large towns (Montreal and Toronto) in the Canadian junction network, as is shown in figure 1.

The curve of the same figure referring to Japan shows the line lengths for inter-office trunks of Tokyo, Osaka and Nagoya, which are among the main metropolitan areas in the country. About 30% of the lengths are shorter than 4 km while repeater spacings of about 8 km allow 80% of offices to be linked without repeaters.

From the curve showing the distribution of lengths in the Federal German network it is seen that a very high percentage of links (more than 80%) has a length of less than 4 km; but, on the other hand, very long links (of more than 20 km) can also be encountered.

In figure 1 the distribution of the distances between switching stations on a large Italian town is shown. A noticeable difference can be observed with respect to the above-mentioned conditions as 100% of the junctions are shorter than 6 km and 80% are shorter than 4 km.

Finally, the distribution of junction system route lengths in the United Kingdom is reported in figure 1. It can be seen that it lies between the curves of Japan and the United States up to 16 km. Link lengths longer than 16 km can more probably be found in the United Kingdom network than in the United States. In particular, lengths in excess of 30 km can be encountered with some percentage of probability.

Economic studies in the United States have indicated that systems operating at 44.7 Mbit/s (corresponding to 672 digital voice channels) are the most economic choice for initial service.

At that bit rate, the first wavelength region (0.8-0.9 μm) with commercial fibres (5 dB/km) and laser diode (LD) sources, a repeater spacing of 6.5 km would eliminate the need for intermediate repeaters in the congested central portion of many metropolitan networks [1] although larger repeater spacing would be required to avoid totally repeaters outside existing telephone central offices. For the Japanese junction network, repeater spacing of more than 15 km is needed for covering 100% the distances between central offices. However, it is fairly difficult to connect existing telephone offices without outdoor repeaters in large cities, because repeater spacing in the wavelength region around 0.85 μm is about 10 and 8 km with LD and light

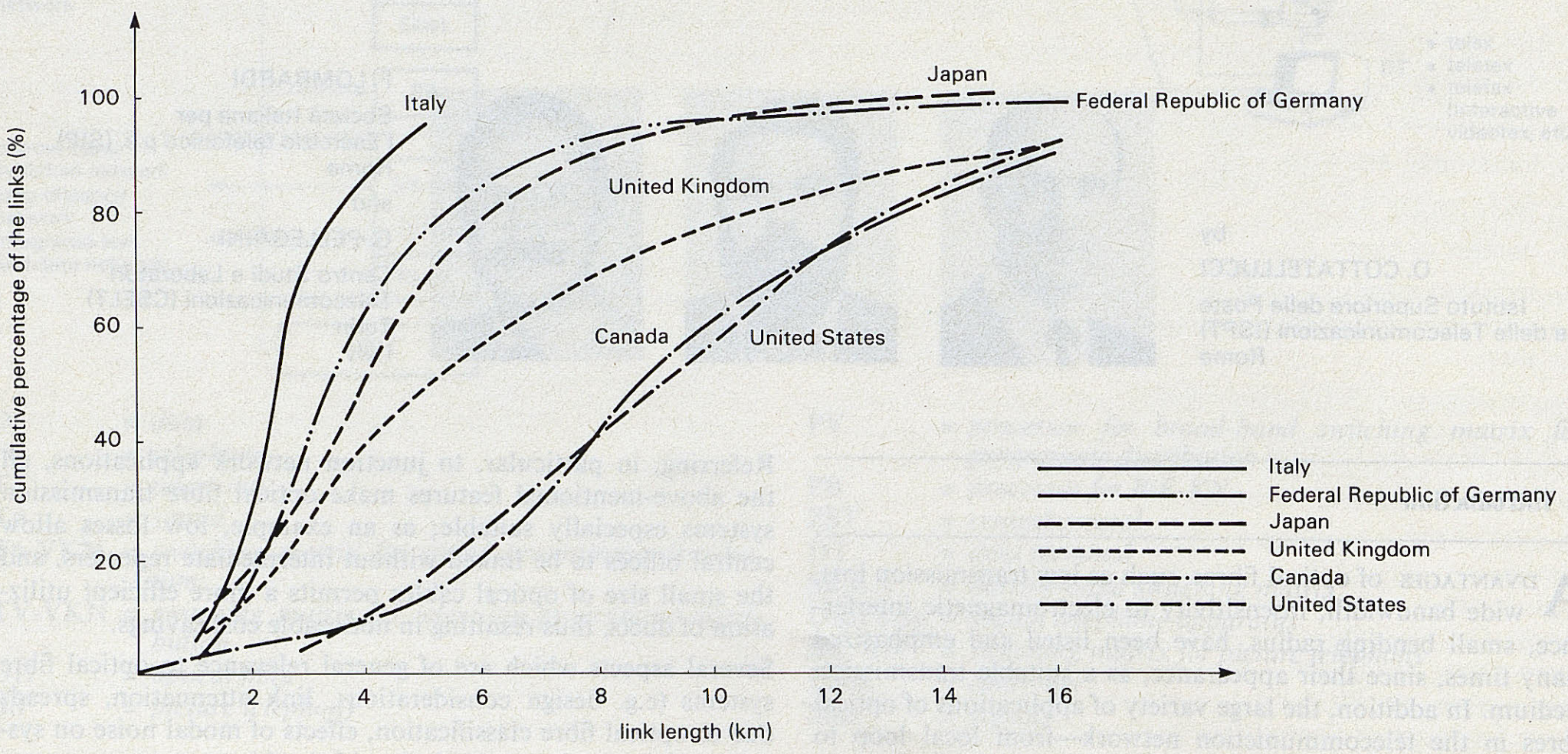


Figure 1—Distribution of span lengths in metropolitan areas

emitting diodes (LEDs) respectively, both at 6 and 32 Mbit/s. In order to make better use of optical fibres it has been suggested, for the longer span lengths, to use the wavelength region around 1.3 or 1.5 μm.

Finally, in the Italian junction network systems operating at 8 and 34 Mbit/s, with LED and commercial fibres, would connect, also at 0.85 μm, the overall existing telephone central offices without outdoor repeaters.

3. Transmission system aspects

When considering transmission system aspects in the junction network, a preliminary remark must be made: trends are definite towards the use of digital techniques as the best suited to this area of application. Indeed, digital transmission systems are already widely used, on inter-office links, in the presently available copper cable network. The introduction of optical fibres in the junction network will then match the needs for evolution towards a fully digital network, as optical devices are particularly suited for transmitting information in digital form.

As far as digital transmission is concerned, the first choice one is faced with is the system bit rate. Taking into account both the length distribution characteristics and the number of circuits in the junction network, there is general agreement in favour of the use of the second and third levels of digital hierarchies. The 6 and 8 Mbit/s systems have characteristics of great flexibility while the 32, 34 and 45 Mbit/s can carry a noticeable number of voice circuits that could be required in inter-office trunks of crowded areas.

Beside the conventional information content, it must be emphasized that these two hierarchical levels have enough information capacity to carry television signals with different methods of redundancy reduction.

The bit rates of the third hierarchical level allow the transmission of standard television signals with very good quality as the redundancy reduction required is very small. As far as the transmission at 6 and 8 Mbit/s is concerned, the signal processing required is more sophisticated; as a consequence the quality can suffer some impairments, which are, on the other hand, largely counterbalanced by the strong reduction of the required bit rate.

As a final consideration about the choice of the proper bit rate, it must be pointed out that, in some particular conditions, [2] higher bit rates can be adopted in inter-office links, due to the very high capacity required.

As far as the digital transmission system design is concerned, the bit rate being determined on the basis of the foregoing considerations, an important role is played by the line code. Its optimum choice depends, beside the system bit rate, on the transmission characteristics of the fibre (mainly the available bandwidth) and on complexity of coding and decoding circuitry. It can be stated that, generally, the larger the fibre bandwidth is with respect to the system bit rate, the simpler can the coding rule be, and hence the coder and the decoder. This simplicity often results in a larger bandwidth occupancy, which is not a drawback for low bit rates.

With reference to the junction network applications there is a general agreement in using 1B2B codes (e.g. CMI) for lower bit rates while codes showing a smaller increase in the symbol rate are preferred for higher bit rate systems. For bit rates corresponding to the third level of digital hierarchy, parity check coding of scrambled signals or 5B6B codes are commonly used. These choices rely on the consideration that, whatever the fibre is, for 6 and 8 Mbit/s systems there is always enough bandwidth to accept signals with double symbol rate; however, for higher bit rates and long repeater spacings, fibre bandwidth could justify an increase in the complexity of coding-decoding circuitry.

An interesting solution for 8 Mbit/s systems in the junction network has been experimented in Italy, on the COS3/FOSTER link in Rome, which makes use of the HDB3-PWM technique [3] allowing the transmission of a three-level signal onto the fibre by modulating the width of transmitted pulses. By means of this choice the signal coming from the multiplex can be directly sent to the driver circuit without transcoding operations, thus resulting in a cheaper line terminal.

Another important item to be taken into account when examining the application of optical fibre systems in the junction network is the possibility of dispensing with remote power feeding.

It really is possible to put repeaters, when needed, in offices where power can be locally supplied. In order to attain this goal, two different approaches can be followed in the system design. The first one consists in trying to reach a repeater spacing equal to the maximum actual distance between two exchanges by using, for instance, very low loss optical fibres, longer wavelength systems (e.g. 1.3 μm) and LD and avalanche photodiode (APD) combinations. The alternative approach, on the other hand, is based on the consideration that in an urban environment it is generally possible to find premises, in which local power feeding can be done, within the range of repeater spacing easily attainable without making use of any special devices or systems.

As far as the check of link performance is concerned, error monitoring seems to be the most suitable means of controlling system quality. Error can easily be monitored by detecting the violations of coding rules; in fact all the systems employed in the junction network use line coding which also allows, besides spectrum shaping and an easy timing recovery procedure, the possibility of monitoring link quality.

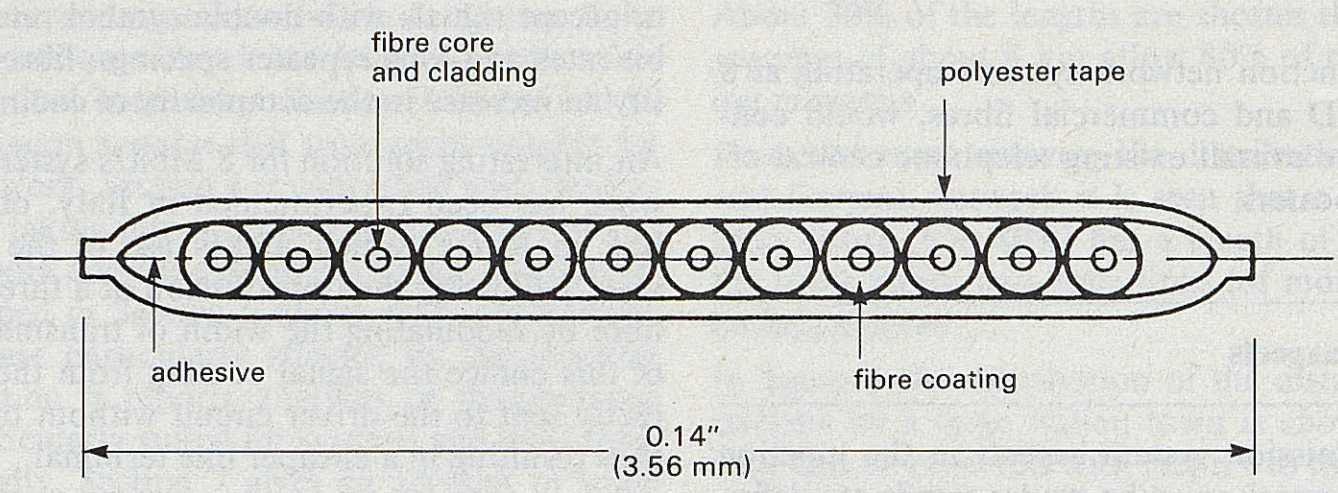
A final remark must be made about the use of wavelength division multiplexing (WDM) technique. By means of this transmission method it is possible to convey, at the same time, several information signals by modulating sources at different wavelengths. It has been shown [4] that this multiplexing technique can be economically advantageous with respect to the conventional digital one (performed by either bit or word interleaving) inasmuch as intermediate repeaters are not needed.

Hence, even though extensive use of such systems is not at present foreseen, the junction network could really profit by this technique as, in general, no intermediate repeaters are used and the possibility of extending the capacity of existing links without adding any further fibres seems very attractive from the point of view of exploitation.

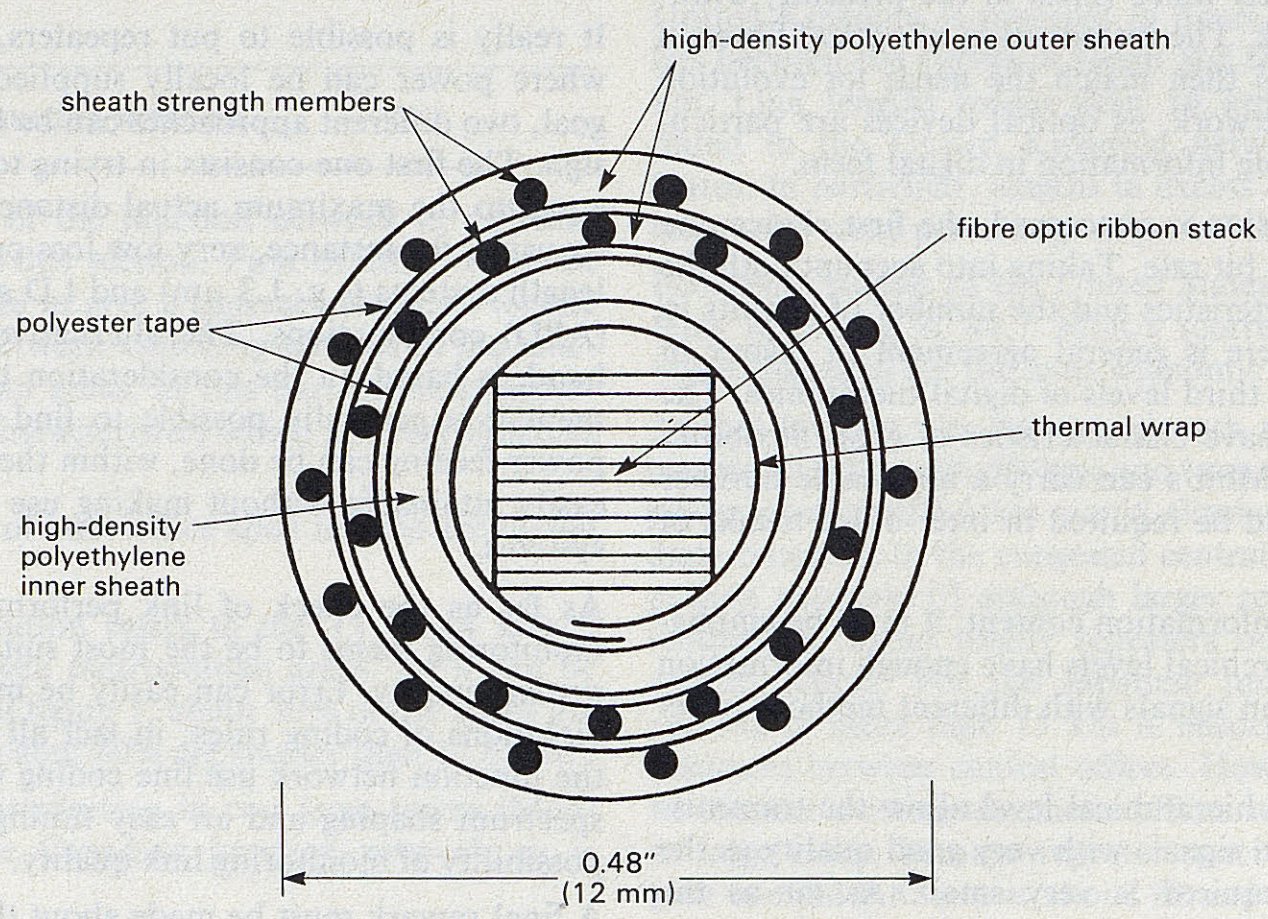
4. Features of optical fibres

Characteristics of optical fibres suitable for junction networks utilization are closely connected with the features both of the junction network and of the transmission systems that have been reviewed in the preceding sections.

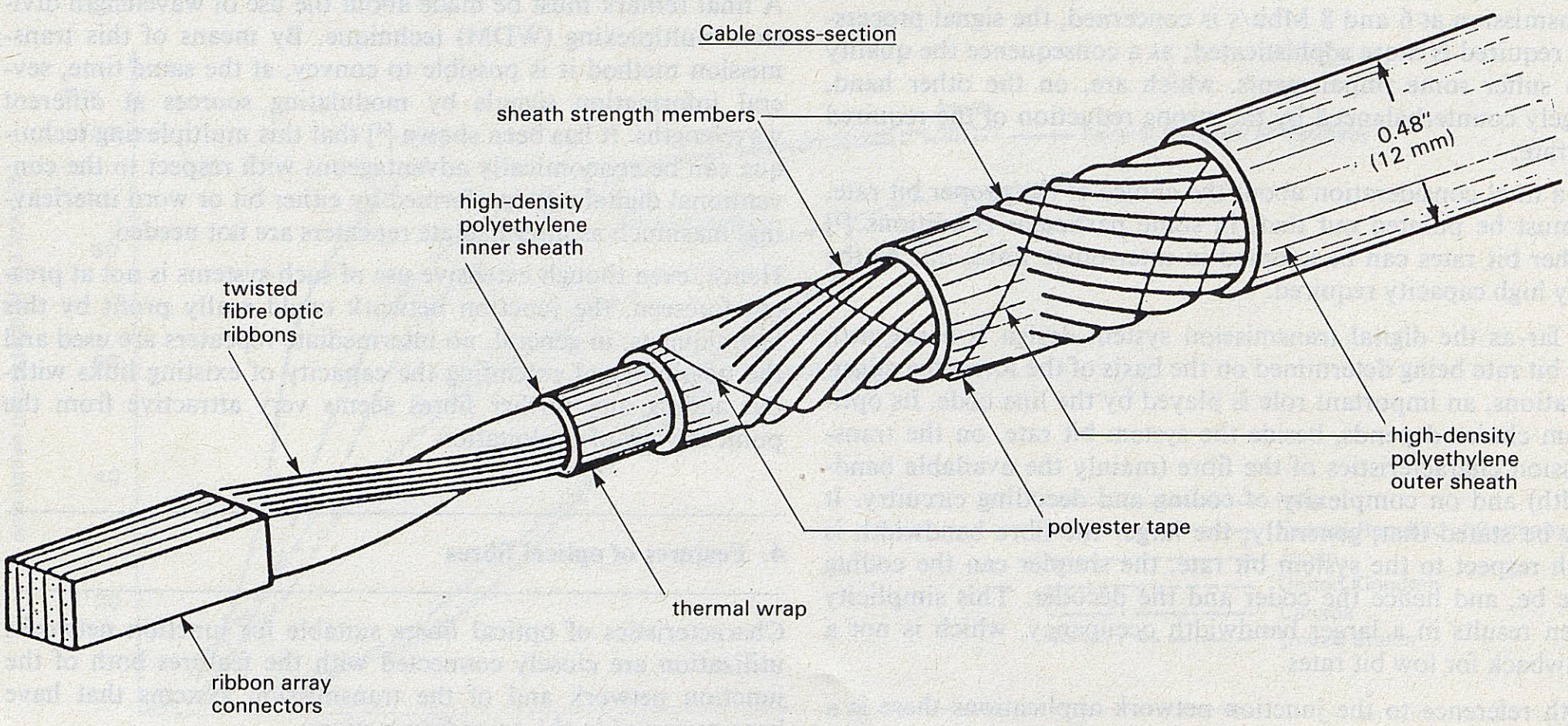
In general, it can be said that optical fibres already developed for long-distance communications seem to be suitable also for this area of the telecommunication network. In particular, grad-



Ribbon design



Cable cross-section



Lightguide cable

Figure 2—Cable structure for FT3 system

ed-index fibres having 50 and 125 μm diameters of core and cladding respectively are of current use in the experiments and foreseen for the links to be put in actual service.

As far as the transmission characteristics are concerned, both attenuation and loss must have values compatible with design objectives relevant to the junction network. In particular, attenuation values in the range 3 - 5 dB/km at 0.85 μm and in the range 0.7 - 1.5 dB/km at 1.3 μm are the most appropriate as they allow the linking of exchanges in the junction network for the different national situations depicted in Section 2. Bandwidth requirements are, in general, less stringent as a consequence of the bit rates most frequently used. In fact, except for situations requiring transmission systems operating at bit rates in the order of 100 Mbit/s, bandwidths of 400 MHz × km or more are in general use. These values permit the repeater spacings needed in the various national junction networks to be obtained.

5. Cable characteristics and laying conditions

This section provides a short review of some optical cable characteristics and laying conditions used in a few field trials carried out in the junction networks of various countries. At present it is difficult to determine the cable structure, the suitable number of fibres, the cabling techniques (e.g. tight or loose jacketing), the presence of metallic pairs, the factory cable length and the protection against moisture.

In fact the requirements imposed by metropolitan digital networks are related to different factors, such as demand for a large number of circuits, various laying conditions (aerial, tunnel, duct or directly buried), widespread distribution of inter-office span lengths and differing maintenance philosophies. As an example, for some applications it is desirable to include copper pairs in the optical cable. This is the normal approach when no local sources of power are available for the dependent repeaters. However, the inclusion of copper pairs in the cable is unlikely to be a long-term solution, since within a few years repeater spacings should be such that intermediate repeaters can be located in surface buildings and locally powered. Dielectric cables are preferable for installation in areas that are liable to be struck by lightning, particularly if the ground resistance is high.

A limit to the optical cable length is given by the length of fibre which can be produced in one operation. Factory cable lengths of 1 km are typical but lengths of over 2 km have also been made, and 5 km lengths are not impossible. Optical fibre cables have been installed in underground ducts in lengths of up to 2.5 km with considerable success, and the installation of longer lengths is being investigated.

Figure 2 shows the cable used for the FT3 system and installed in several locations in the United States. The individual fibres are packaged in ribbons containing 12 fibres each and then, up to a maximum of 12 ribbons, are enclosed in a protective sheath to complete the cable. The outside diameter of the sheath is approximately 12 mm and is independent of the number of fibres contained in the ribbons. Such cable is attractive from the splicing standpoint because the premeasured lengths are connectorized at the factory and then installed and spliced together in the outside plant to form a continuous optical transmission path. In general, before the installation of the optical cable having 12 mm of outer diameter, a polyethylene inner duct with an internal diameter of 24 mm is installed inside the existing old tile duct. The inner duct provides a controlled environment for the optical cable as well as a simple method of pressurizing around the optical cable. No copper pairs are included in the cable, because the repeaters are locally powered in inter-office exchanges, while auxiliary circuits, including order wire, telemetry and gas pressure monitoring, are sent on copper pairs in an adjacent cable.

Figure 3 shows an example of the structure of 24-fibre cables laid in Kawasaki and planned for commercial use by Nippon Telegraph and Telephone Public Corporation (NTT).

The 24-core cable has a concentric layer structure. There is a tension strength member in the cable centre, which is surrounded by one layer containing six quads of interstitial copper wires and four units consisting of 24 fibres. Fibres designed for 0.85 and 1.3 μm transmission are used.

The unit outer diameter is of 4 mm while the overall outer diameter is of 24 mm. Another type of two-layer structure is also used for 48-fibre cables, as shown in reference [5]. The route cable includes 11.1 km ducts and 6.5 km aerial lines. Installation lengths into ducts are about 1100 m on average (maximum 1550 m). Installation lengths for aerial lines are about 830 m on average (1280 m). The maximum cable tension is below 300 kg throughout the installation; the installed optical fibre cables were designed to withstand more than 600 kg tension.

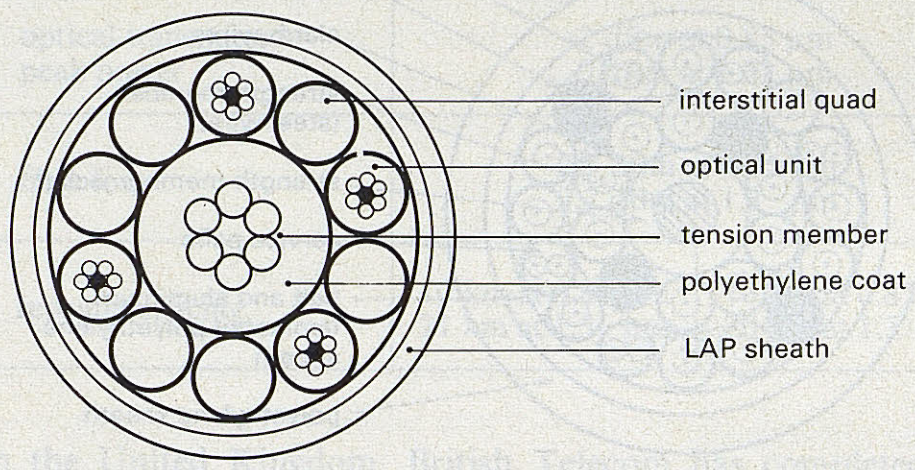


Figure 3—Optical fibre cable in the field trial in Kawasaki

Figure 4 shows the cable structure of the first field trial in the Paris junction network, organized by the French PTT. The basic structure is a cylindrical plastic core reinforced by a central member. Helical V-grooves are primarily intended to receive coated fibres, and thin plastic tapes are used to close the grooves. A unit cable has 10 grooves with 4 mm outside diameter. Such a unit can be used directly and protected by suitable sheaths. In figure 4 is also shown the instlled 70-fibre cable, in Paris, obtained by stranding some units before applying the final sheaths. The average loss of 500 km of fibres after cabling is about 2.5 dB/km in the first window.

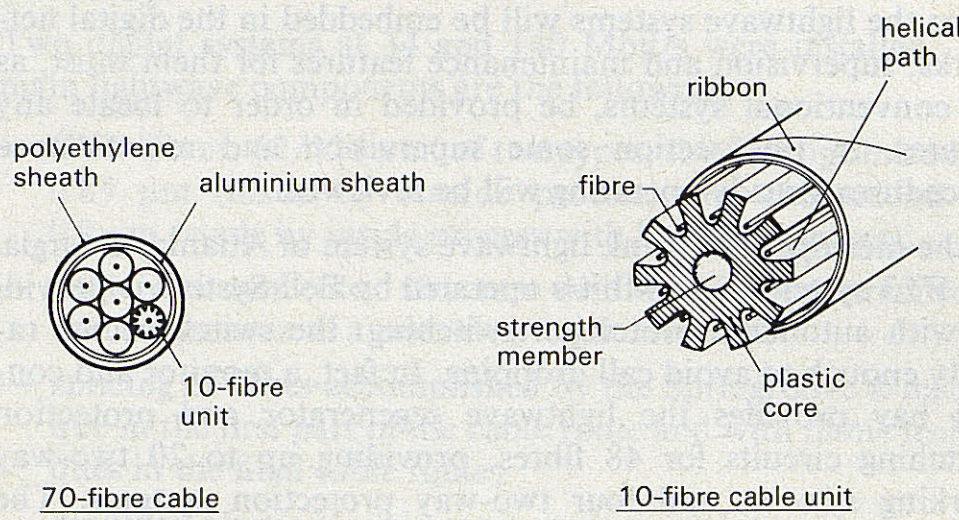


Figure 4—Cable section of the type used by the French PTT

Finally, figure 5 shows the cable of the COS3/FOSTER field trial in the Rome junction network, [6] organized by the *Azienda di Stato per i Servizi Telefonici* (ASST) and SIP. The cable contains 18 fibres and has a concentric structure in which the fibres, each protected by a loose polypropylene jacket of about 2 mm external diameter and about 1 mm internal diameter, are stranded in two layers around a central strength member consisting of a polyethylene coated steel wire. The cable has a high pneumatic resistance and thus it is not pressurized; however, it contains two alarm wires to detect water penetration. The cable laid in ducts is protected by a polyethylene sheath with an internal Al-laminated polyethylene longitudinal tape as water barrier and it has an overall diameter of 17 mm. Moreover, the cable directly buried has an additional protection given by a belt, a corrugated steel tape and an outer polyethylene sheath, giving an overall diameter of 27 mm.

The cable route has been chosen in order to allow different laying conditions; in fact, there are 4 km laid in tunnels, 10.7 laid in ducts and 1.8 km directly buried. Typical pulling length has been about 1 km, with a pulling strength not exceeding 140 kg.

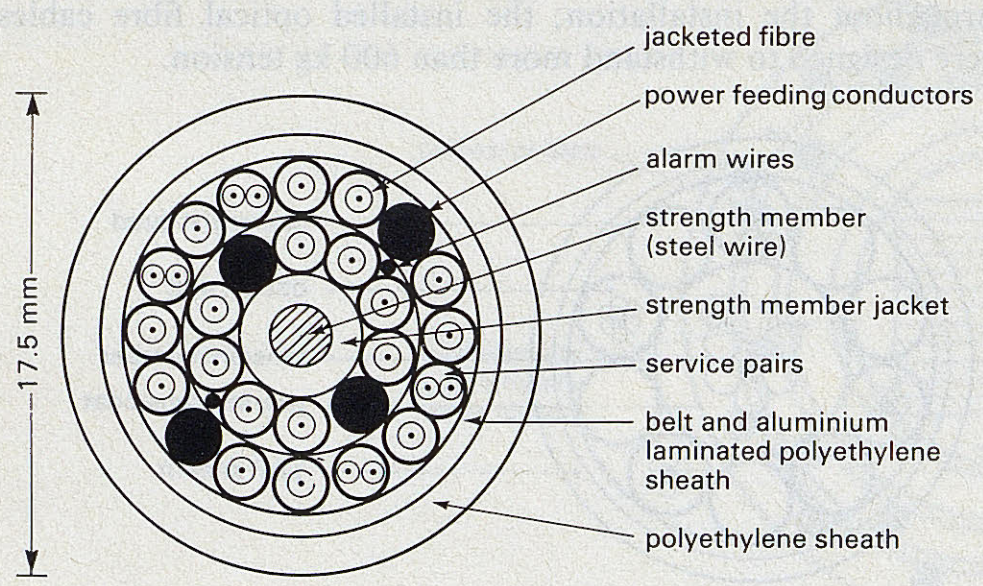


Figure 5—COS3/FOSTER cable cross-section

As far as laying in ducts is concerned, it has been necessary to solve problems relating to the coexistence of the optical cable with already existing conventional copper cables. In this case, the optical cable has been laid within a 40 mm polyethylene sub-duct, previously inserted in the 120 mm duct already housing a coventional coaxial cable.

6. Supervision and maintenance

Since the lightwave systems will be embedded in the digital networks, supervision and maintenance features for them must, as for conventional systems, be provided in order to locate any failures. In this section some supervision and maintenance procedures already operating will be reviewed.

In the metropolitan trunk lightwave system of Atlanta, Georgia, the FT3 system at 45 Mbit/s operated by Bell System is provided with automatic protection switching: the switch occurs rapidly enough to avoid call dropping. In fact, a monitor and control bay provides the lightwave regenerator and protection switching circuits for 48 fibres, providing up to 20 two-way working systems and four two-way protection systems. The lightwave line is switched out of service when an error rate of 10^{-6} is detected and is restored when the error rate is better than 10^{-7}. To faciltate installation and maintenance of the FT3 system, the following test sets are provided:

- an optical loss measuring instrument, to ensure that regenerator section losses are within allowed limits;
- an optical time domain reflectometer, to check the quality of splices and to locate cable breaks;
- an FT3 line test set, to provide a signal source and receiver for use in fault-locating regenerators (a loop-back fault-locate procedure is used, and a special low-frequency test signal is employed to stress the regenerators);
- MX3 (terminating multiplex at 45 Mbit/s) error rate test set providing input signals at different hierarchical bit rates and for error monitoring at these rates.

In the NTT inter-office transmission systems of Kawasaki city, an ordinary parity check code is adopted as supervising method for a digital transmission line and a pilot level detection check is used for analogue transmission lines. Moreover, six items are supervised in digital transmission systems, that is: synchronization, baseband signal input to transmission equipment, output power degradation and bias current increase of laser diode, power supply and fuse. When a circuit is out of order, fault location is performed at the main station (supervising and control station) and the error rate of each repeater is measured in a loop circuit. System switches are employed in electrical stage to improve system reliability. A system switch, for 24-fibre cable, has 11 bidirectional working channels and 1 standby channel, which are switched manually.

In the Italian COS3/FOSTER field trial, terminals of different transmission systems, at 34 and/or 140 Mbit/s, are being installed in each exchange. A permanent check of parameters allowing an exhaustive description of any equipment on trial has been provided. A test equipment for automatic collection of parameters characterizing the system under trial has been built. [7] In order to allow simultaneous tests on systems installed in five of the exchanges, the equipment has been structured in a central unit and five peripheral measurements apparatuses, one for each exchange.

Each peripheral equipment can record values of the following parameters, which are kept under continuous control:

- error rate;
- percentage of error-free seconds;
- supply voltage of the photodetector and AGC current at the receiving side;
- modulation current of the source at the transmitting side;
- alarms provided by the system manufacturer.

The central unit is connected, through a service pair included in the optical cable, to the five peripheral measurement apparatuses and records on a magnetic tape all the parameters listed above.

The recorded values, in order to have essential information on an occurred fault, are printed when one of the parameters assumes a value out of fixed range. These values are related to the 15 minutes preceding the fault. In this way it is possible to have the information on the degradation preceding the system fault.

Finally, it must be emphasized that the possibility of using, in the future, a completely dielectric cable, gives rise to the need for using optical fibres also for carrying service and alarm information: this can be done either by utilizing a fibre in the cable devoted only to this purpose, or by using fibres that carry real traffic.

7. Practical experiences

Economic evaluations carried out during the past years have shown that lightwave systems are also most promising for metropolitan applications. Moreover, the large capacity of fibres is well matched to circuit requirements of the junction network in metropolitan areas, the small cable diameter allows a most efficient utilization of ducts and the achievable repeater section makes it possible, in many cases, to avoid intermediate manhole repeaters. For these reasons, in various countries different field trials and fully developed fibre optic transmission systems have been planned. In this section several of these metropolitan lightwave systems will be reviewed.

The first fully standard application, in the United States, was completed for Atlanta, by September 1980.

The cable route, 45 km long, connects four terminal sites and five repeaters with the maximum repeater section of 6.5 km between inter-office local exchanges.

The main lightwave components of the FT3 digital transmission system are the following:

— multimode graded-index fibre (50/125 μm);
— ribbon-structured 12 mm diameter cable, 12 fibres per ribbon, up to 12 ribbons for cable;
— etched V-groove silicon-chip ribbon connector (cable is factory connectorized);
— moulded plastic biconic single fibre connector;
— GaAlAs double heterostructure laser transmitter (0.82 μm wavelength);
— silicon avalanche photodiode receiver.

The maximum repeater spacing of the FT3 system is approximately 6.5 km, although further reductions in fibre loss and other system improvements are expected to increase this distance in the future.

Table 1 summarizes the main characteristics of the FT3 system.

Table 1

average transmitter power	–3 dBm
minimum received power	–48.5 dBm
allowance for end connector losses	–3 dB
allowance for 14 splices	7 dB
cabled fibre loss	5 dB/km
unallocated system margin	3 dB
repeater spacing	6.5 km

One of the main field trials using optical cable was installed by NTT in Kawasaki, near Tokyo, in 1980. In the field trial test, three telephone offices are connected along a 11.5 km underground duct-route, with fibre cables including 24 or 48 graded-index fibres. In addition to the duct-route, a 6.3 km aerial route is also constructed in a loop via a manhole. Three digital transmission systems, at 6.3, 32 and 100 Mbit/s respectively, and one analogue video transmission system have been installed in three telephone offices. The main lightwave components of the systems are the following:

— MCVD and VAD fibres (50/125 μm) designed for 0.85 μm and MCVD fibres optimally designed for 1.3 μm;
— cable structure with 6-fibre unit, standardized for 24 or 48 fibres;
— InGaAsP LD and LED at 1.3 μm and GaAlAs LD sources at 0.85 μm;
— Si-APDs and Ge-APDs at 0.85 and 1.3 μm respectively.

In table 2 the main characteristics of a digital system operating at 32 Mbit/s and of the video analogue system are summarized.

Table 2

transmitted signals	32 Mbit/s	analogue video
line format	1B2B code	PFM
optical transmitted peak power	+2 dBm at 0.85 μm 0 dBm at 1.3 μm	
fibre loss	2.8 dBm at 0.85 μm 0.7 dBm at 1.3 μm	
repeater spacing	10 km at 0.85 μm 21 km at 1.3 μm	10 km at 0.85 μm 20 km at 1.3 μm

In the United Kingdom, British Telecom has completed the first phase of its programme for the installation of 28 commercial operational 8 and 34 Mbit/s systems on 12 routes in the junction network. A second phase, involving the installation of a further 137 systems, also operating at 8 and 34 Mbit/s, is now well under way. The original systems operated in the first window (0.85-0.9 μm) and employed lasers or LED, and APD. The more advanced systems now utilize the second window at 1.3 μm and use LED and PIN-FET receivers. The systems have repeater spacings of up to 16 km depending on the system type.

The first commercial systems in Italy were installed in Rome in 1981 by SIP and ASST. The cable (having the overall length of 16 km) connects seven main local exchanges of both organizations in the metropolitan area of Rome. As has been said in Section 5, the cable route was chosen as it had different laying conditions.

Two digital systems at 34 and 140 Mbit/s were installed. The main lightwave components are the following:

– CVD fibres, 62/125 μm, of two types, the first optimized for 0.85 μm (made by outside process) and the second for 0.9 μm (made by inside process with low OH content);
— cable with concentric structure with the 18 fibres stranded in two layers around a central strength member;
— splicing of fibres accomplished by the Springroove ® technique in the first part of the cable route and with flame techniques in the final cable route;
— moulded plastic biconic connector;
— LED operating at 0.8 and 0.9 μm and LD at 0.85 μm.

The main characteristics of the two digital systems are summarized in table 3.

The first fibre optic plant in France was installed in 1980, in Paris, by the French PTT. The optical line consists of a 70-fibre cable pulled in ducts on a 7.5 km route between two exchanges. [8] The main characteristics of the link are:

— MCVD fibres;
— cylindrical V-grooved type of cable;
— mass-splicing for connections between cables;
— wavelength 0.85 μm and bit rate at 34 Mbit/s.

The main characteristics of the 34 Mbit/s system are summarized in table 4.

Finally, during 1979, the *Deutsche Bundespost* carried out a field test with optical fibre communication links in Berlin. [9]

The optical link, 4.3 km long, connects two local exchanges, in the junction network in Berlin-Wilmersdorf.

The equipment used in the field trial was implemented for 34 Mbit/s digital system with LED and LD sources working at 0.85 μm.

Table 3

transmitted signals	34 Mbit/s	140 Mbit/s	
wavelength (μm)	0.85	0.9	0.85
sources	LED	LED	LD
detector	Si-APD		
average transmitter power (dBm)	−15		0
minimum receiver power (dBm)	−50		−46
allowance for end connector losses (dB)	−4		2
cable attenuation (splices losses included) (dB/km)	6	3	3.7
material dispersion penalty (dB)	4	4	—
system margin (dB)	3	3	5
repeater spacing (km)	4	8	10.5

Table 4

transmitted signals	34 Mbit/s
wavelength (μm)	0.85
sources	LD
minimum receiver power (10^{-9}) (dBm)	−50
average attenuation for the total spliced link (dB)	27 at 0.85 μm 11 at 1.3 μm
average total bandwidth (MHz)	220
repeater spacing (km)	7.5

8. Conclusions

The junction network is the part of the telecommunication network that can profit soon from the well-known useful characteristics of optical fibre systems.

In fact, it has been shown that digital transmission systems, operating in the first window ($\lambda \simeq 0.85$ μm), have already reached a development stage which can guarantee actual utilization. The achievable repeater section for digital systems at the second or third hierarchical levels, operating at 0.85 μm, allows a large percentage of links in the junction network to be implemented without intermediate repeaters and, hence, without problems connected, for instance, with remote power feeding.

In addition, the large variety of length distributions of the links in the junction network in various countries makes very attractive the use of longer wavelength system (e.g. $\lambda \simeq 1.3$ μm) as the very long repeater spacings attainable in that spectral region allow 100% of the exchange offices to be linked without intermediate repeaters. Of course, besides technical feasibility, economic convenience also needs accurate assessment in order to make fully effective the choice of longer wavelength optical fibre systems.

A final remark must be made on the suitability of the WDM technique: in fact WDM can become very attractive for use in the junction network, either because of the possibility of increasing the traffic capacity of fibre or the economic savings that can be achieved with respect to the use of higher hierarchical levels of equivalent capacity.

(Original language: English)

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The application of optical fibres in the trunk network

by
C. J. LILLY
British Telecom
United Kingdom

1. Introduction

THROUGHOUT the history of radio and carrier telephony there has been a continuing trend to the use of higher frequencies. This is primarily because it is generally more economic to obtain additional capacity by exploiting higher frequencies than to have a number of co-routed lower capacity systems.

The use of optical frequencies (i.e. around 3×10^{14} Hz) in trunk transmission systems has come about as a result of a number of major breakthroughs.

The first was the development of a practical light source by Maiman in 1960 [1] which led to the later development of semiconductor lasers, which are much used as the optical light source in optical fibre transmission systems. The concept of using glass fibres as a transmission medium was suggested in a paper published in 1966 by Kao and Hockham.[2] At this stage optical fibres had losses of the order of 1000 dB/km. The next major breakthrough came in 1970 with the achievement of fibres having losses of 20 dB/km by Corning Glass Works.[3]

Since that time major advances have occurred in every area of the technology to the point where many varieties of system have now been developed and installed in realistic and practical environments around the world.

2. Trunk networks

It is worth while clarifying what exactly is meant by the term "trunk network". For the purpose of this paper it is taken to be that network which permits the connection of circuits between secondary and tertiary switching centres (exchanges or offices) or between two secondary or tertiary switching centres which are physically located in different areas or regions.[4,5] In North America it is commonly known as the "toll network". The trunk network should not be confused with the junction (or inter-office) network, which usually comprises routes within major conurbations having lengths of typically 5-20 km.

Trunk systems, on the other hand, can vary enormously in length from under 20 to over 300 km and in some instances to as much as 1000 km in length. Trunk network routes, by definition, are major routes used for carrying traffic between major conurbations. As such there is generally a requirement for systems on such routes to have a high capacity in order to minimize circuit costs.

3. Digital optical fibre systems

Optical fibre systems can be designed to operate utilizing either analogue or digital techniques. However, with the advent of integrated digital networks and the fact that much greater repeater spacings can be achieved when operating in the digital regime (with consequent economic advantages), optical fibre systems for application in trunk networks are invariably of the digital type. The advantages of digital optical fibre systems for trunk networks may be summarized as follows:

— very large repeater spacings compared with equivalent capacity metallic cable systems and therefore less intermediate equipment required;

— very large information bandwidth and therefore a potentially high transmission capacity;

— potentially low material cost (for the optical fibres);

— small cable size leading to low duct occupancy;

— negligible crosstalk;

— high immunity to interference;

— complete electrical isolation.

There are also distinct economic advantages to be had in the use of optical fibre systems in trunk networks [6] as shown in figure 1.

The speed of operation of digital trunk optical fibre systems is based on two principal hierarchies [7] which are shown in table

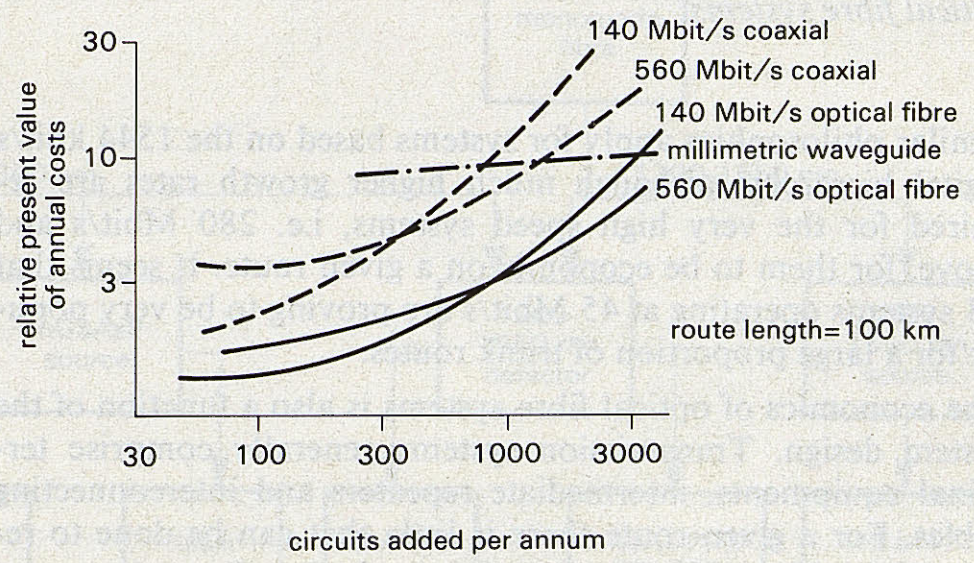

Figure 1—Cost comparison using different line transmission media

Table 1

CCITT digital hierarchies

hierarchy based on 2048 kbit/s primary order multiplex (kbit/s)	hierarchy based on 1544 kbit/s primary order multiplex (kbit/s)
2048	1544 (T1)
8448	6312 (T2)
34368	32064
139264	44736 (T3)

1. The choice of system(s) to be employed in a given trunk network depends predominantly on the economics of provision. Trunk routes generally have relatively high growth rates and it is often economic to install systems operating at the higher bit rates, typically 34 Mbit/s and above. In many countries employing the 2048 kbit/s digital hierarchy, systems operating at 34 and 140 Mbit/s are considered to be the most economic, the 34 Mbit/s systems being viable on lower growth rate trunk routes, i.e. 10-100 circuits added per year, whereas 140 Mbit/s systems are more viable on the higher growth rate routes, i.e. greater than 100 circuits added per year. A typical graph showing economic comparisons is shown in figure 2.

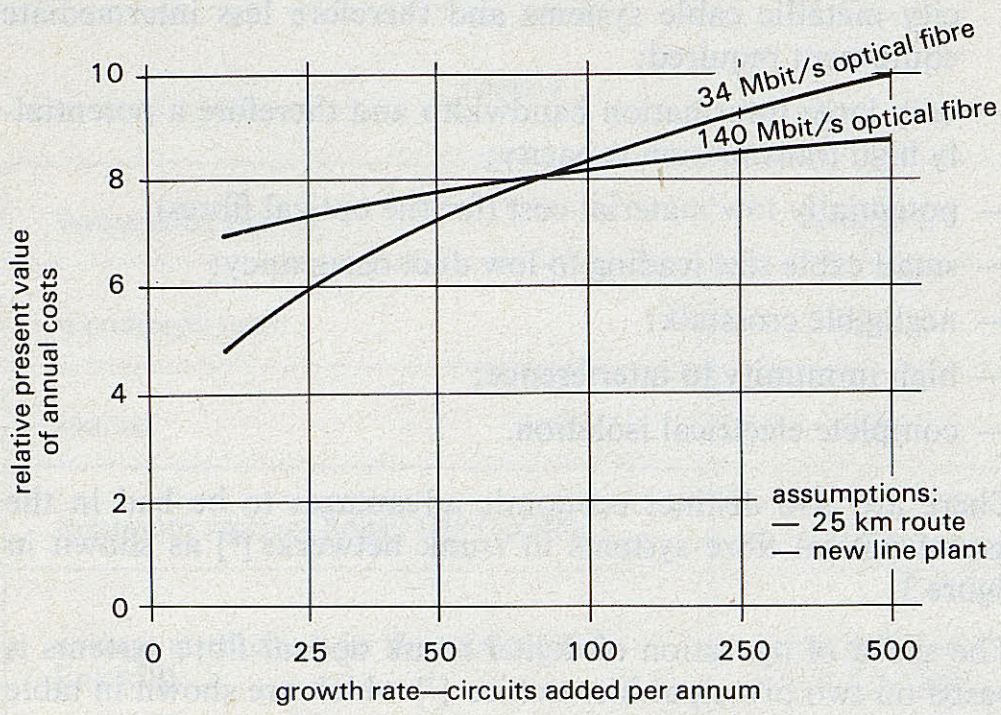

Figure 2—Economic comparison between 34 and 140 Mbit/s optical fibre systems

Similar philosophies apply for systems based on the 1544 kbit/s digital hierarchy, although much higher growth rates are required for the very high speed systems, i.e. 280 Mbit/s and above, for them to be economic on a given route. It seems that T3 systems operating at 45 Mbit/s are proving to be very popular for a large proportion of trunk routes.

The economics of optical fibre systems is also a function of the system design. Transmission systems generally comprise terminal equipments, intermediate repeaters and interconnecting cables. For a given route there is little that can be done to reduce the cable cost other than by employing the most appropriate cable design for each application.[8] However, total equipment costs can be reduced quite dramatically if the spacing between intermediate repeaters can be increased, thereby reducing the required number of such intermediate repeaters for a given route. It is for this reason, amongst others, that considerable research and development effort is being expended in an attempt to maximize repeater spacings.

4. System configuration

Before pursuing a detailed discussion of trunk systems design it is perhaps worth while to define the basic system configuration. The general arrangements for a typical system are shown in block diagram form in figure 3. This arrangement comes about as a result of the need to have a terminal equipment at each end of the system (often called "line terminating equipment"—LTE—or "lightguide cable interconnecting equipment"—LCIE), for interfacing and other purposes. On routes where the route length exceeds the design repeater spacing, then it is necessary to have intermediate repeaters which may be housed in intermediate buildings, in underground equipment housings or, in the case of some aerial routes, on the tops of poles. For systems which do not have their repeaters located in surface buildings it is necessary to provide power to the repeaters, usually by means of a power feed sub-system. This often necessitates the use of a surface building at intervals along the route, from which power can be supplied to adjacent repeaters. The advantage of achieving repeater spacings which permit the repeaters to be located in surface buildings, and thus be locally powered, will be only too apparent.

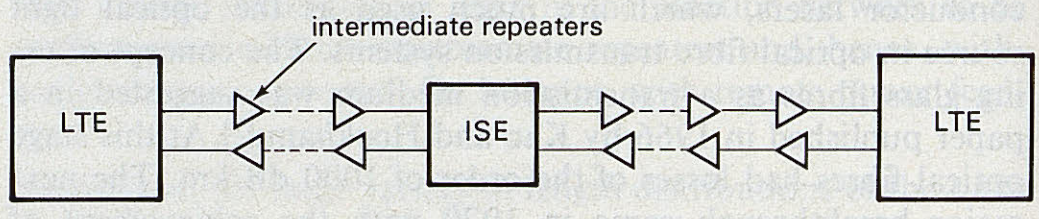

Figure 3—Typical system configuration

LTE = *line terminal equipment*
ISE = *intermediate station equipment*

The building blocks which go to make up the terminal and repeater equipments are shown in figures 4 and 5. These are discussed in more detail in Section 6 of this paper.

5. Overall system design

Some of the more fundamental parameters which have to be decided before detailed system features can be resolved are shown in figure 6. The design process is often an iterative one involving the continual reprocessing of design data until an optimum system design can be configured. Nevertheless, as a starting point it is usual to decide first upon the speed of operation. Such a decision will be based on economic and operational factors as mentioned in Sections 2 and 3 above. The speed of operation, once decided, automatically yields data on preferred interfaces, as recommended by the CCITT [9] and on system performance.[10]

The derived repeater spacing may not necessarily be the longest which is technically feasible. This is because to achieve long repeater spacings very high quality optical fibre has to be used,

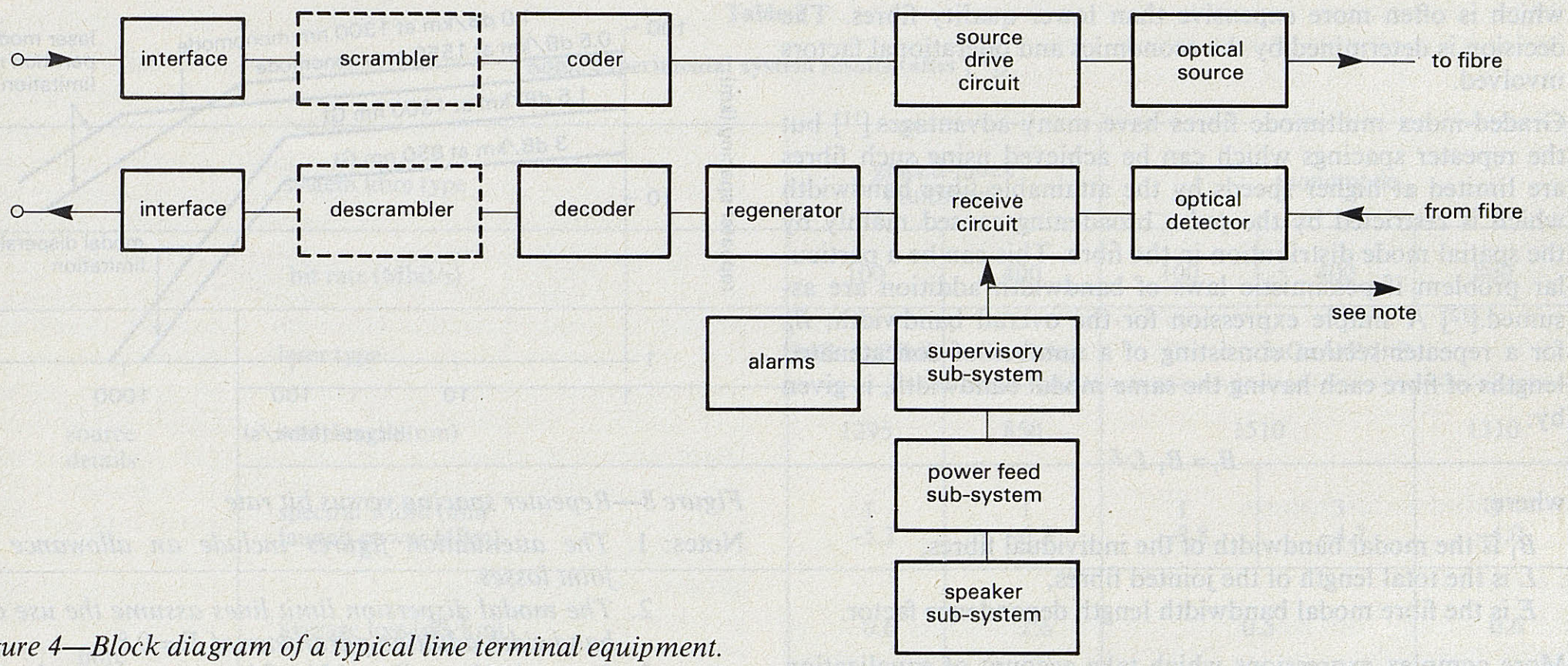

Figure 4—Block diagram of a typical line terminal equipment.
Sub-system connections may be to optical fibres and/or metallic conductors—see text for details (Section 7)

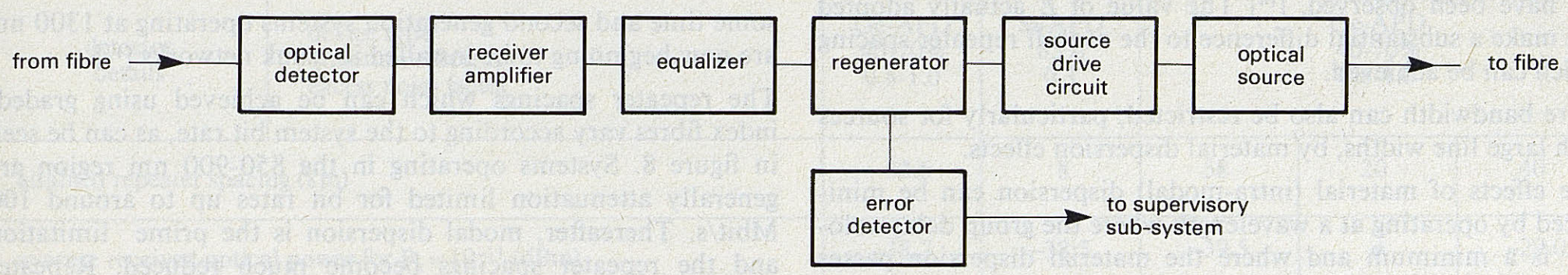

Figure 5—Block diagram of a typical intermediate repeater

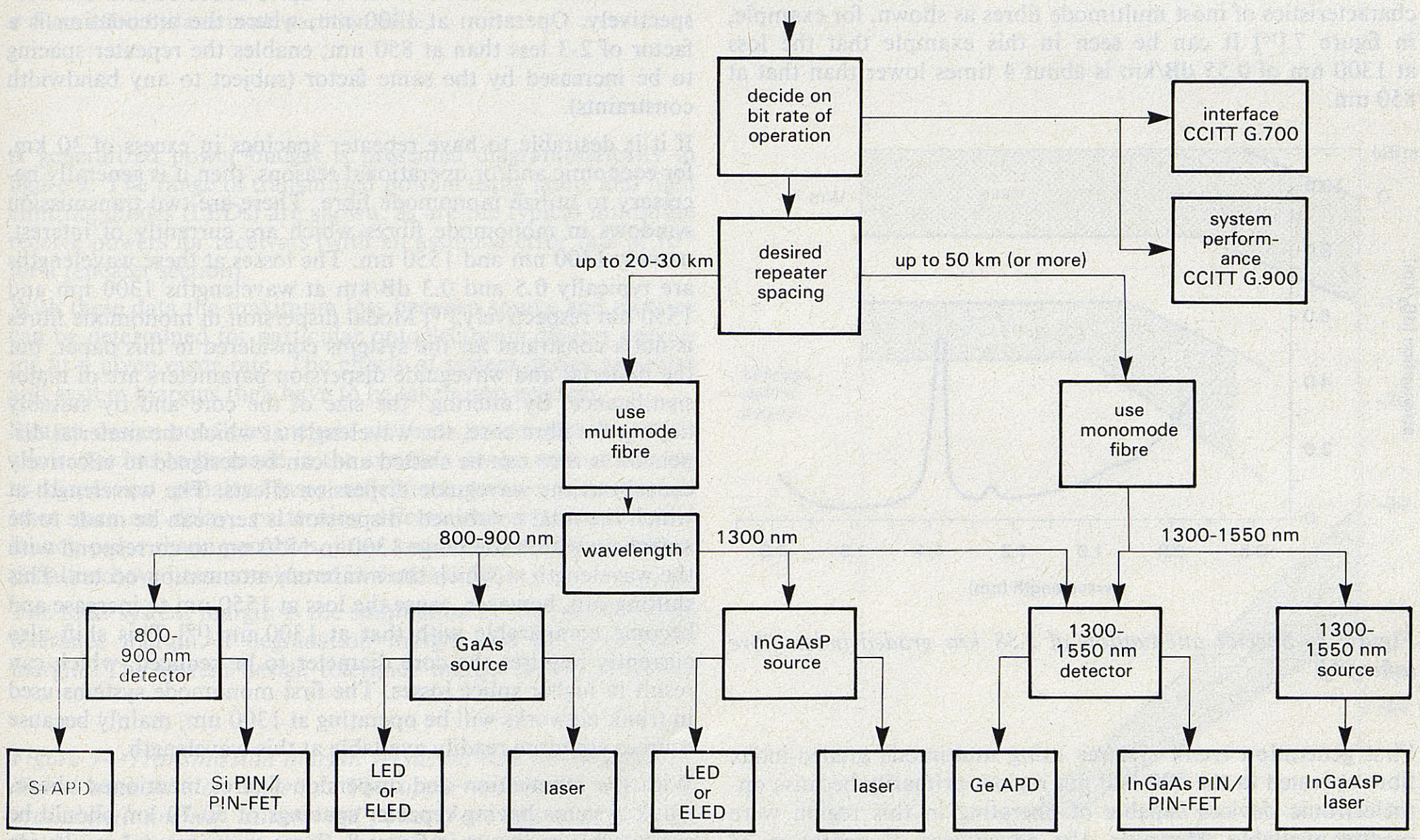

Figure 6—Some fundamental system design decisions

which is often more expensive than lower quality fibres. The decision is determined by the economics and operational factors involved.

Graded-index multimode fibres have many advantages [11] but the repeater spacings which can be achieved using such fibres are limited at higher speeds by the attainable fibre bandwidth which is restricted by the pulse broadening caused mainly by the spatial mode distribution in the fibre. This can be a particular problem if pessimistic laws of bandwidth addition are assumed.[12] A simple expression for the overall bandwidth, B_t, for a repeater section consisting of a number of concatenated lengths of fibre each having the same modal bandwidth, is given by:

$$B_t = B_1 \, L^{-E}$$

where:

B_1 is the modal bandwidth of the individual fibres,
L is the total length of the jointed fibres,
E is the fibre modal bandwidth length dependence factor.

More complex expressions which take account of equalization effects between fibres have been published in the literature.[12,13]

Values of E ranging from 0.5 to 1.0 and in some cases down to 0.3 have been observed. [14] The value of E actually adopted can make a substantial difference to the overall repeater spacing which can be achieved.

Fibre bandwidth can also be restricted, particularly for sources with large line widths, by material dispersion effects.

The effects of material (intra-modal) dispersion can be minimized by operating at a wavelength where the group delay velocity is a minimum and where the material dispersion passes through zero, typically around 1300 nm.[15] Operation at 1300 nm also coincides with a low loss window in the attenuation characteristics of most multimode fibres as shown, for example, in figure 7.[16] It can be seen in this example that the loss at 1300 nm of 0.55 dB/km is about 4 times lower than that at 850 nm.

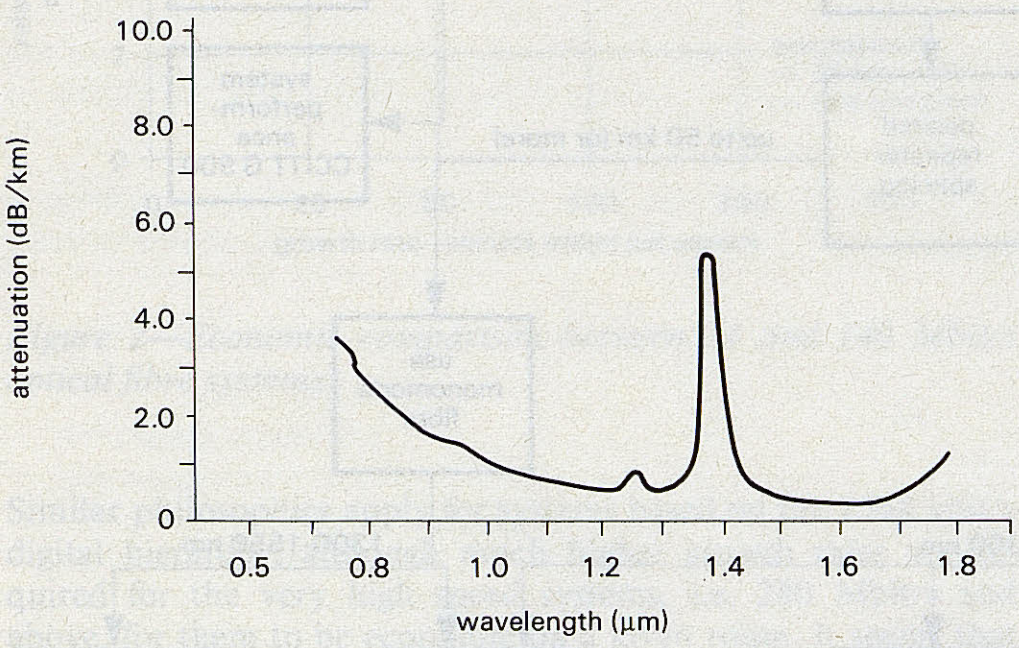

Figure 7—Special attenuation of 2.38 km graded-index fibre (after [16])

First generation trunk systems using multimode graded-index fibre operated in the 800-900 nm region, primarily because optoelectronic devices capable of operating in this region were readily available. However, the advantages of operation at wavelengths of around 1300 nm have been clearly apparent for some time and second generation systems operating at 1300 nm are now beginning to be installed in trunk networks.[17]

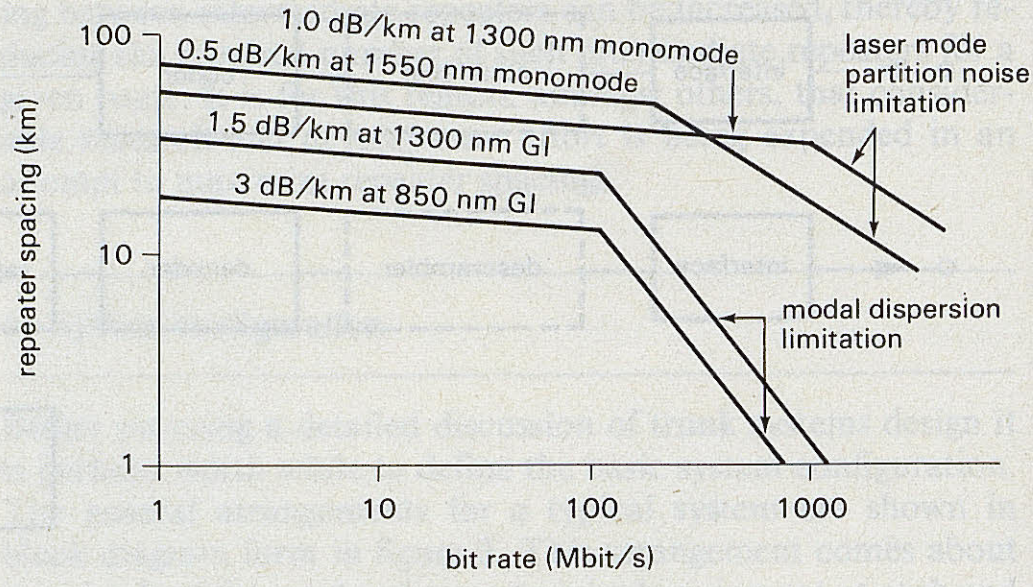

Figure 8—Repeater spacing versus bit rate

Notes: 1. *The attenuation figures include an allowance for joint losses*
2. *The modal dispersion limit lines assume the use of a bandwidth addition parameter of* E = *0.8*
3. *Lasers having a linewidth of 4 nm are assumed*
4. *Laser mode partition noise limitation assumptions after [22]*

The repeater spacings which can be achieved using graded-index fibres vary according to the system bit rate, as can be seen in figure 8. Systems operating in the 850-900 nm region are generally attenuation limited for bit rates up to around 100 Mbit/s. Thereafter, modal dispersion is the prime limitation and the repeater spacings become much reduced. Repeater spacings for trunk systems operating at 34 and 140 Mbit/s on multimode fibre at 850 nm can be up to about 13 and 8 km respectively. Operation at 1300 nm, where the attenuation is a factor of 2-3 less than at 850 nm, enables the repeater spacing to be increased by the same factor (subject to any bandwidth constraints).

If it is desirable to have repeater spacings in excess of 30 km, for economic and/or operational reasons, then it is generally necessary to utilize monomode fibre. There are two transmission windows in monomode fibres which are currently of interest, namely 1300 nm and 1550 nm. The losses at these wavelengths are typically 0.5 and 0.3 dB/km at wavelengths 1300 nm and 1550 nm respectively.[18] Modal dispersion in monomode fibres is not a constraint for the systems considered in this paper, but the material and waveguide dispersion parameters are of major significance. By altering the size of the core and by suitably doping the fibre core, the wavelength at which the material dispersion is zero can be shifted and can be designed to effectively cancel out the waveguide dispersion effects. The wavelength at which the total combined dispersion is zero can be made to be anywhere within the range 1300 to 1550 nm to correspond with the wavelength at which the minimum attenuation occurs. This shifting can, however, cause the loss at 1550 nm to increase and become comparable with that at 1300 nm.[19] This shift also currently requires the core diameter to be reduced, which can result in higher splice losses. The first monomode systems used in trunk networks will be operating at 1300 nm, mainly because sources are more readily available at this wavelength.

With the attenuation and dispersion figures mentioned above, trunk systems having repeater spacings of 50-70 km should be achieveable as shown in figure 8. Some experimental results are tabulated in table 2.[20-22]

Table 2

Some experimental system results (after [20])

system fibre type		graded-index multimode		monomode		
bit rate (Mbit/s)		100	400	100	400	800
source details	laser type	InGaAsP/InP	GaA1As	InGaAsP/InP		
	wavelength (nm)	1295	850	1510		1310
	spectral width (nm) launch power (dBm)	1 –5.3	1 –6.5	1 –7.8	3 –4.7	3 –4.0
fibre details	average loss (dB/km)	0.6	2.6	0.5		0.6
	dispersion	1.3 GHz-km		16 ps/km/nm		2 ps/km/nm
detector details	device type quantum efficiency excess noise factor	Ge-APD 40-70% 0.8-1.0	Si-APD 65% 0.3	Ge-APD 40-70% 0.8-1.0		
attained repeater spacing (km)		52.6	8	58	20	40
average received optical power for $P_e = 10^{-11}$ (dBm)		–38.7	–38.5	–39.5	#	–29.0

Floor effect by laser mode partition noise.

A generalized power budget is presented diagrammatically in figure 9. The range of transmitted powers using lasers and light emitting diodes (LEDs) are shown, as are the typical minimum receive powers for receivers (with an assumed error rate of 10^{-9} for a repeater section).

With these data the maximum loss between source and receiver can be determined for particular optoelectronic devices operating at a given error rate. The effects of system design penalties and system margins then have to be taken into account.

System design penalties include all those parameters for which allowance has to be made in the system's design and such items as dispersion penalty, laser reflections (where appropriate), laser turn-on delay, patterning effects and extinction ratio, launch pulse shape penalties, jitter and mis-equalization. These penalties have been considered in detail in [23].

The total system margin is the summation of the system design tolerance margin, a degradation margin and a maintenance margin. The system design tolerance margin is the allowance

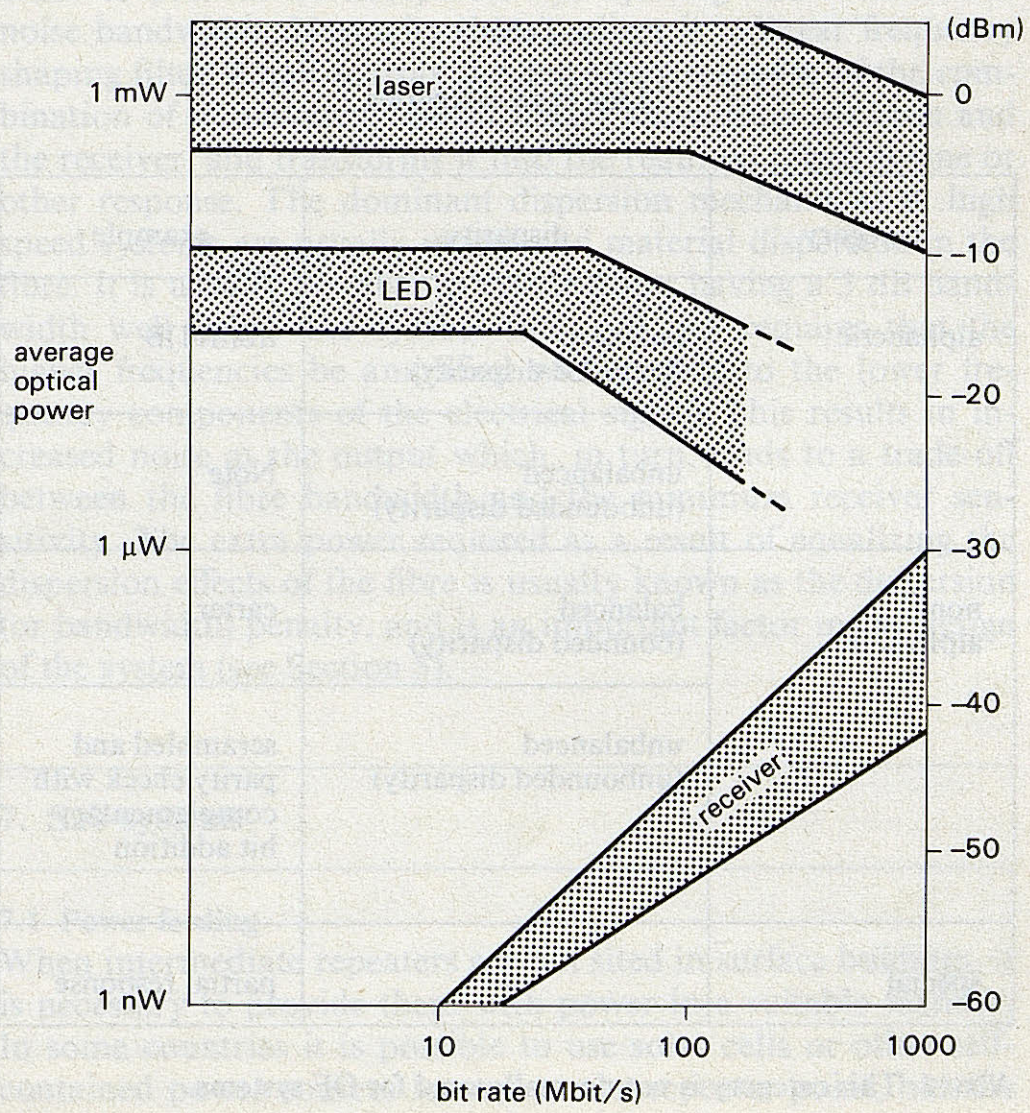

Figure 9—Transmission margin versus bit rate for optical fibre digital transmission systems. The upper two bands represent available (launched) transmitted power from lasers and LEDs: the lower band represents the required received power for 10^{-9} error probability (after [24])

for all tolerances on such parameters as fibre, splice and connector losses, source output power, laser patterning, receiver sensitivity, etc. The system degradation margin includes an allocation for the effects of time and temperature on the various system parameters, e.g. fibre loss, source output power, receiver sensitivity, etc. Finally, the system maintenance margin is the allowance which must be made for additional splices and maintenance replacement cable lengths which might be necessary during the life of the system.

The quantification of these various margins is a complex task. Various values for the total system margin have been utilized up to around 10 dB on various systems.[14,24].

6. Detailed design features

6.1 Line coding

As has already been mentioned, the system interfaces shown in figure 4 are defined by the CCITT.[10] For 34 Mbit/s systems the interface code is HDB 3 and for 140 Mbit/s systems it is CMI. These codes are generated either by the preceding multiplex equipment or by a LTE in a preceding line system.

The interface code is seldom suitable for use as the line code for the transmission systems and is therefore usually encoded in the transmit part of the LTE. The general requirements for line codes are given in [23]. In addition, it is worth noting that it is sometimes desirable to use line code redundancy to provide terminal-to-terminal communication for engineering speaker facilities and supervisory telemetry purposes. There are potentially a large number of line codes, any one of which might be chosen for a particular application.[25] The broad categories of line code are shown in table 3.

Various studies have been carried out on optimum line codes for use on trunk optical fibre systems. Favoured codes appear to be the balanced binary block codes of the nB(n+1)B type. 5B6B and 7B8B codes have been employed with good results on 34 and 140 Mbit/s systems respectively and partial response techniques have been proposed for the higher speed systems, e.g. 560 Mbit/s and above.[26]

Table 3

Line code categories

category	disparity	example
alphabetic	balanced (bounded disparity)	nB(n+1)B
	unbalanced (unbounded disparity)	Note 1
non-alphabetic	balanced (bounded disparity)	carter
	unbalanced (unbounded disparity)	scrambled and parity check with complementary bit addition
special	—	partial response

Note 1: This category is not normally used for OF systems.

Table 4

Summary of typical source device performance

device type	system wavelength (nm)	material	typical output power coupled into 50/125 µm graded-index fibre (nW)	typical modulated linewidth (nm)	maximum modulation frequency (MHz)
laser	850 1300 1550	GaAlAs InGaAsP InGaAsP	1-3 0.1-2 0.1-2	3 8 10	500 500 500
ELED	850 1300	GaAlAs InGaAsP	1-1.5 0.5-1.5	40 60	100 200
LED	900 1300	GaAs InGaAsP	0.5-0.8 0.1-0.5	40 110	50-150 50-150

The use of scrambling techniques is not uncommon and indeed scramblers have many advantages, since they improve:

— realignment times of block codes;
— timing extraction;
— jitter accumulation;
— signal level detection;
— imperfections due to low frequency cut-off;
— dynamic range;
— transmission of alarm indication signal (AIS);
— excess digital run variation error detection.

They also make possible mark parity error detection. For these improvements there is a sacrifice in the form of impairments in the error ratio and error spread if self-synchronizing scramblers are employed.

6.2 Optical sources

Once the data have been suitably coded they are usually then used to directly modulate the optoelectronic source device. The commonest sources for trunk optical fibre systems have already been briefly mentioned in Section 5 of this paper and in some detail in [27]. For convenience, the main characteristics of the first generation of each of the devices are given in table 4. The majority of high capacity systems used in trunk networks to date, have operated at a wavelength of around 850 nm and have employed GaAlAs lasers. This is because of the higher output power available from such devices, together with their high modulation speed capability, good launch efficiency and much reduced spectral linewidth. Light emitting diodes, although emitting less optical power than lasers and having considerably wider spectral linewidths, are generally significantly cheaper, easier to utilize (they require less sophisticted drive circuitry), and have very desirable proven lifetimes. As a result they are often employed on lower speed systems, such as those operating at 34 and 45 Mbit/s, for instance. Devices operating at the longer wavelengths of 1300-1600 nm, where the lower attenuation re-

gion of fibres can be exploited, generally use III-V compounds such as InGaAsP.

Semiconductor light sources are almost invariably directly modulated by the applied electrical signal current. The optical transmitter design is largely determined by the optical power/drive current characteristics of the source. The transmitter drive circuit switches the current that modulates the source device. In the case of a LED, operated by a binary (two-level) signal, this may simply involve switching between zero or near zero current and a preset maximum. The same technique cannot be applied to lasers because the variation of threshold current with temperature requires the provision of a feedback loop. Precision control of the modulation may also require the provision of a second feedback loop. In the case of systems operating at bit rates of up to about 565 Mbit/s and used for trunk network applications, it is desirable to switch the laser from a point usually just below the threshold, so as to minimize switch-on delay and other secondary effects such as transient spectral broadening. Laser systems usually, therefore, have a feedback control system whereby optical power from the back facet is monitored by a photodiode, the feedback current from which is used to ensure that the laser is operated within its defined design limits. When the laser is operated from a point close to the threshold, there will be a small amount of light emitted when a "0" is being transmitted. This small amount of optical power, as a percentage of the optical power transmitted during a "1", is known as the extinction ratio and has to be allowed for in systems design, since it contributes to the system design penalty (see Section 5).

The problems of modal noise [28] reflections [29] and mode partition noise [30] in lasers are well documented and are beyond the scope of this paper.

6.3 Fibre and cable

Fibre and cable designs have been discussed in some detail in references [8,11,31]. Almost without exception, fibres used in trunk systems have been of the silica type, fabricated by one of the more common fabrication processes such as modified chemical vapour deposition (MCVD) or vapour axial deposition (VAD). The majority of operational trunk systems installed to date have used multimode graded-index fibres but, as already discussed, the advantages of using monomode fibre are considerable and an increasing number of trunk systems utilizing monomode fibre will be installed in the future.

As reference [8] suggests, there are a large number of assorted cable designs currently in existence, most of which have performed more than adequately. Some rationalization is obviously necessary, but discussion of this subject is beyond the scope of this paper.

6.4 Detectors and receivers

Optical fibre systems used in trunk network applications invariably use a semiconductor photodiode as the optical detector. The various types and their performance are described in reference [32]. The theory, as applied to detectors and receivers, in particular the noise calculations for determining receiver performance, is discussed in reference [23]. A summary table of the features and performance of some detector devices commonly employed in trunk systems is given in table 5. Avalanche photodiodes (APD) have been commonly used in trunk systems operating in the 800-900 nm range because of their high sensitivity. However, they do require high voltages (e.g. 200-400 V) and are temperature sensitive.

Moreover they are not as sensitive as some other devices at longer wavelengths. As a result, more and more use is being made of the PIN-FET technique [32] which overcomes these disadvantages, particularly in the 1300-1550 nm wavelength range.[33]

The signal generated by the photodiode has to be amplified and two techniques are common in current designs of trunk system. The first is a high impedance design in which the photodiode load resistance is made high such that its thermal noise contribution is negligible. The receiver response is then dominated by the input capacitance (a combination of the photodiode capacitance and the input of the amplifier). The other popular approach is the use of a transimpedance receiver design in which the photodiode drives a lower input impedance feedback amplifier. These approaches are discussed more fully in [23].

Table 5

Summary of typical detector device performance

device type	material	system wavelength range (nm)	quantum efficiency (%)	minimum receive power at 140 Mbit/s for $P_e = 10^{-9}$ dBm
APD	Si Ge	800-900 1300-1550	≃ 80 ≃ 70	–50 –40
PIN/PIN-FET	Si InGaAs	800-900 1300-1550	≃ 90-95 ≃ 40-70	–45 –44

6.5 Equalization

On high performance trunk systems, equalization of the amplified electrical signal is usually required prior to regeneration in order to provide an acceptable eye opening and to limit the noise bandwidth. Normally the equalizer is a linear frequency shaping filter which accepts the frequency response of the combination of transmitter, optical fibre transmission medium and the receiver, and transforms it into the required raised cosine or other response. The dominant dispersion mechanisms in high speed systems are usually modal and material dispersion in the fibre. It is usually possible to utilize fibres having a 3 dB bandwidth well below the symbol rate, but this requires that the higher frequencies be amplified with respect to the lower frequency components of the electrical signal. This results in increased noise at the output which, in turn, leads to a trade-off between the fibre bandwidth and the minimum receiver sensitivity. The extra power required as a result of equalizing the dispersion effects of the fibre is usually known as the dispersion (or bandwidth) penalty, and is an important factor in the design of the system (see Section 5).

7. Sub-systems

7.1 Power feeding

When intermediate repeaters are not sited in surface buidings, it is necessary to provide them with power in a suitable manner. In some countries it is possible to use solar cells or other self-contained power sources located at the repeater point, but the

majority of trunk systems usually employ some form of power feeding, whereby power is fed over metallic conductors from surface buildings en route.

Power feed systems currently employed tend to be similar to those used on coaxial transmission systems, often involving the use of constant current end-to-end power feed arrangements.[34]

The need to employ metallic conductors in many ways detracts from the originally foreseen potential advantages of optical fibre systems and, for this reason, considerable attention is being devoted to maximizing repeater spacings in order to be able to locate intermediate repeaters in surface stations and thereby reduce the need for, and even eliminate, power feed sub-systems.

7.2 Supervisory

There is usually a maintenance requirement to monitor the overall performance of the optical fibre system and, in addition, to be able to determine the location of equipment and cable faults. Overall system performance monitoring is usually carried out at the receive terminal where the error rate, which is probably the most important parameter, is usually continually monitored.

On trunk systems, which can often span many hundreds of kilometres, it is necessary to be able to locate a faulty repeater section from a terminal station. Supervisory sub-systems are therefore often incorporated, which monitor the performance of individual repeaters and transmit the information back to a terminal or other staffed building, where appropriate action can be taken by maintenance staff should a fault occur. A number of techniques have been suggested for the supervisory telemetry link, including the use of:

- metallic conductors;
- separate dedicated optical fibres;
- transmission optical fibres using:
  - wavelength multiplexing,
  - line code redundancy,
  - modulation of the line code clock frequency,
  - insertion of additional modulated carrier.

7.3 Engineering speaker

It is often a requirement, particularly on long trunk routes, for maintenance staff to be able to communicate between various points along the system. Two techniques are of particular interest for the provision of this facility.

Firstly the use of metallic conductors enables audio communications from any point on the system, including a cable fault remote from a repeater point, to any other point on the system. Many optical fibre cable designs permit the inclusion of a small number of metallic conductors for this purpose. An alternative approach, which has been shown to be feasible over short distances, is the use of an audio channel formed between a metallic strength member, often made of steel, which can be coated with a layer of copper to improve transmission performance, and a metallic moisture barrier, often made from aluminium, but which can also be coated with a thin layer of copper.

A second technique utilizes the optical fibre by making use of redundancy in the line code. Such a technique is very convenient for providing an end-to-end engineering speaker channel(s) but, of course, access to the speaker circuit can only be gained at locations where there are line coders and decoders.

The use of radio is a third technique which can often be utilized on the shorter trunk routes but it is not generally used for long-haul systems.

8. System realization

The last decade has seen a large number of optical fibre system field trials installed throughout the world, operating at speeds suitable for use in trunk networks.[35] These trials have provided much valuable data and given network operators the confidence in optical fibre technology which was needed before operational systems could be installed in any quantity.

Already a substantial amount of information is being gained from operational systems [14] and key indicators of system performance such as error rate and availability have shown them to be fully acceptable. An important and interesting facet is the difference in repeater spacings achieved on experimental links where ideal operating conditions can usually be maintained, compared with those achieved on operational traffic-carrying commercially available systems. Figure 10 illustrates this, perhaps not surprising, disparity. The relentless increase in repeater spacings, particularly at the higher bit rates, as new techniques are exploited, is also quite apparent.

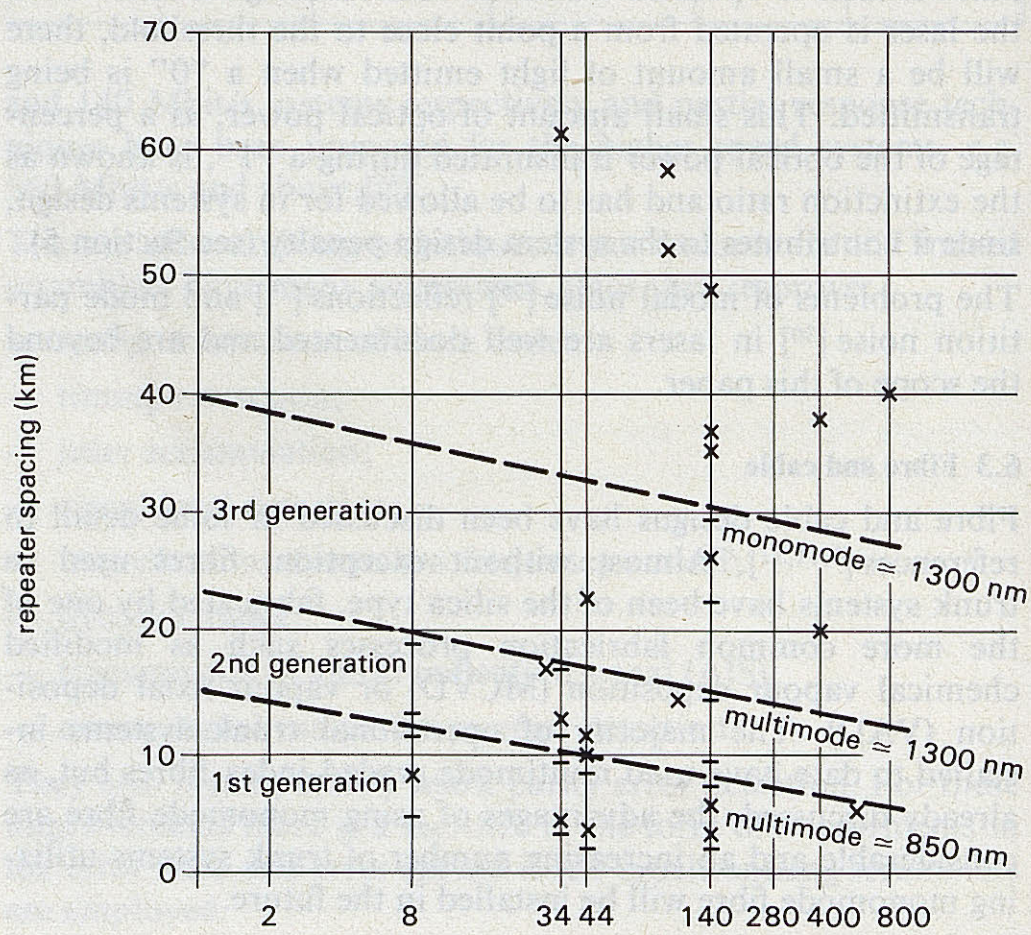

Figure 10—Experimental and commercially attained repeater spacings for trunk networks

x *represents experimental repeater spacing*

I *represents range of repeater spacings for commercially available systems as at date of publication*

Trunk optical fibre systems have been found to be relatively easy to install and to involve no more maintenance than other digital systems using metallic cables.[36]

9. System implementation

Operational optical fibre systems for commercial service are now beginning to be installed in quite large quantities in a number of countries around the world. Ambitious plans are

already being implemented in various countries including the United Kingdom, France, Federal Republic of Germany, Italy, United States and Japan amongst others.[37-39]

Trunk systems for commercial service operating at 34 and 140 Mbit/s appear to be popular in the United Kingdom and elsewhere in Europe. In the United Kingdom, economic studies have indicated that 140 Mbit/s optical fibre systems are actually more cost effective than comparable systems on coaxial pairs. As a result, a total of over 80 such systems, requiring almost 10 000 fibre-km were ordered in 1979 and in 1981, for installation in just the United Kingdom trunk network alone over the next few years.[17] The most recent order includes 140 Mbit/s monomode standard systems, having a repeater spacing of nearly 30 km, which are required for commercial operational use. In France, a 140 Mbit/s multimode system has been ordered by the French Administration, for a 100 km route between Le Mans and Angers. The repeater spacing for this link is planned to be 25 km. In the United States, systems operating at 45 Mbit/s are currently the norm in the toll network, with a number of operational systems installed in Atlanta, Pittsburgh and elsewhere. Particularly noteworthy is the plan for a long-haul network along the United States Northeast Corridor, linking Boston, New York City and Washington, operating at 45 Mbit/s over a total route length of 1077 km. In Canada a system operating at 280 Mbit/s in Alberta is being installed as part of a transcontinental high capacity trunk network link. In Japan, some very long systems operating at 400 Mbit/s and at a wavelength of 1300 nm have been demonstrated and installed, and there are plans for large-scale implementation of the technology.

A list of experimental and operational systems is given in reference [35].

10. Conclusions

The first generation of optical fibre systems for trunk network applications is currently being installed. These systems, operating in the 800-900 nm wavelength region on graded-index multimode fibres, are now being fast superseded by the second generation of systems operating at around 1300 nm. Operation at this latter wavelength, on multimode fibre, permits the use of light emitting diodes, as well as lasers, whilst still achieving very acceptable repeater spacings.

The third generation of systems are those using monomode fibre. Systems of this type have been demonstrated in a number of laboratories and already a number of such systems are planned for commercial and operational use.

Whilst it has taken, perhaps, some 15 years for the necessary research and development to be carried out, many administrations and operating agencies throughout the world are now realizing the advantages of employing optical fibre systems in their trunk networks. As a result, systems are now being installed at an unprecedented rate.

The pace of research is unlikely to slacken, however, and one can envisage many developments over the next decade or so, such as integrated optics and, possibly, ultra-long wavelength operation (i.e. 4-10 microns), which will doubtless bring about further generations of enhaced performance systems in due course.

(Original language: English)

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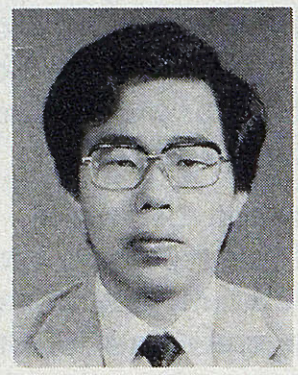
The application of optical fibres in submarine cable systems

by I. YAMASHITA
Yokosuka Electrical Communication Laboratories
Nippon Telegraph and Telephone Public Corporation (NTT)

Y. NEGISHI
Ibaraki Electrical Communication Laboratories
NTT



M. NUNOKAWA
and
H. WAKABAYASHI
Research and Development Laboratories
Kokusai Denshin Denwa Co., Ltd. (KDD)
Japan

1. Introduction

During the past two decades, submarine telephone cable systems using coaxial cables and frequency division multiplexed analogue transmission have achieved remarkable increase of circuit capacity to satisfy increasing traffic demand and have been offering high quality circuits. The circuit capacity for a recent system is a hundred times more than that of 25 years ago. However, with the advent of optical fibre telecommunication technology, the evolution of submarine cable systems over the next ten years is expected to be different from that of coaxial systems.

Optical fibre cables, which have vast potential bandwidth coupled with small size, are an attractive proposition for future submarine cable systems. Submarine optical fibre systems will almost certainly be digital and it is envisaged that they will offer a lower cost per circuit than conventional metallic cable systems. Several organizations are therefore actively developing submarine optical fibre cable systems for commercial service in the 1980s and beyond.

2. Background [1-4]

2.1 Coaxial systems

The increases in circuit capacity of coaxial systems have been achieved solely by increases in bandwidth, accompanied by the inevitable decreases in repeater spacing and increases in cable diameter. Figure 1 and figure 2 show the repeater spacing and the cable core diameter respectively for coaxial systems as a function of circuit capacity. It is evident that the repeater spacing decreases and the cable diameter increases as the capacity increases. It is likely that the repeater spacing and the armourless cable diameter will be about 4 km and 50 mm respectively in a sytem carrying around 10 000 circuits.

Larger capacity systems, working at higher frequency, have to use larger diameter cable in order to contend with increasing attenuation, and result in shorter repeater spacing which requires higher reliability of repeater circuit and higher power feeding voltages. Larger diameter cables are already an expensive pro-

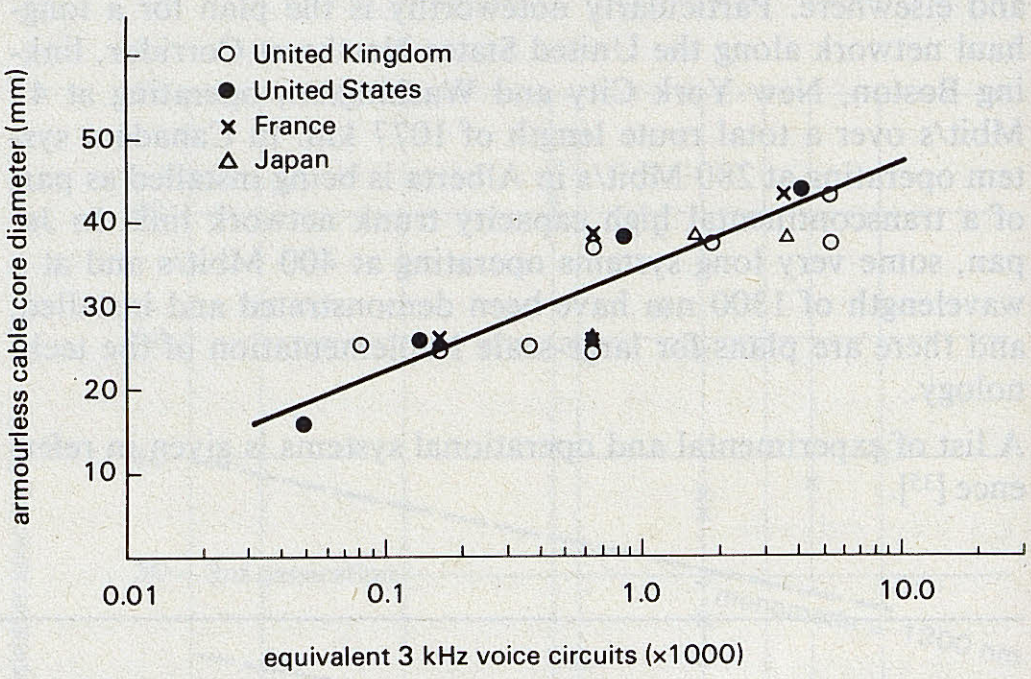


Figure 1—Repeater spacing for coaxial submarine cable systems

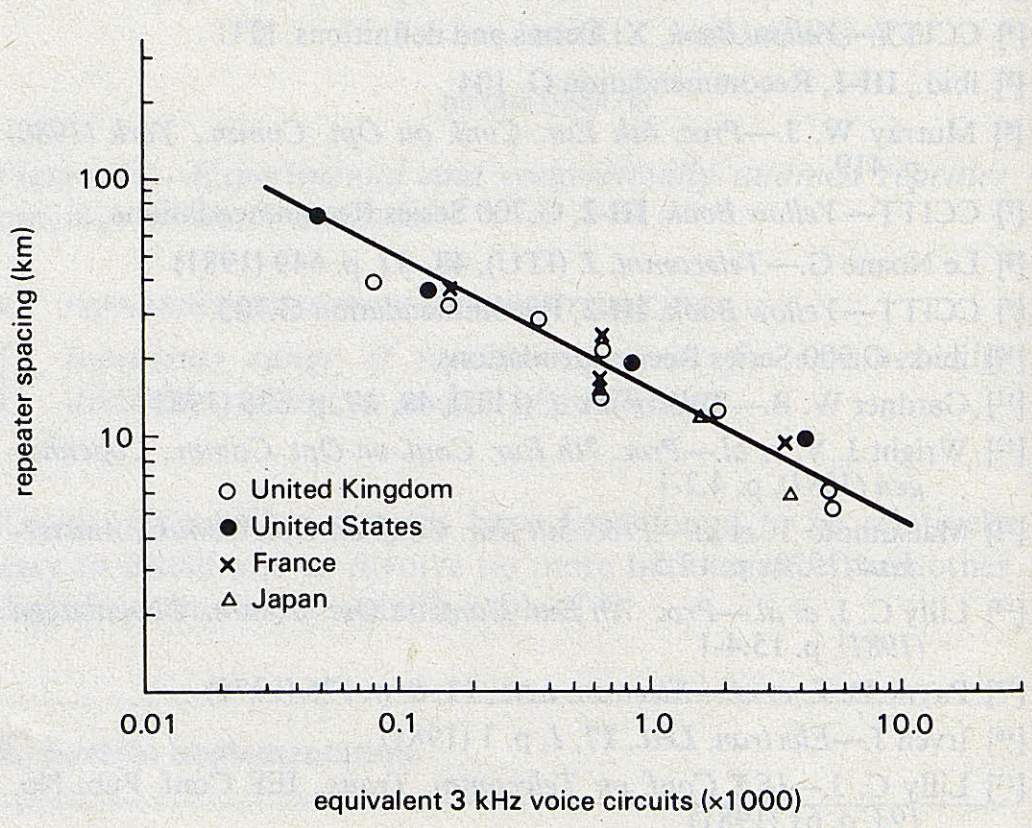


Figure 2—Cable core diameter for coaxial submarine cable systems

portion of system cost and will also make it hard to handle laying and recovery operations.

2.2 Optical fibre systems

Optical fibre communication technology offers an attractive possibility of large capacity submarine cable systems with longer repeater spacing, coupled with smaller size cable, because optical fibres have very low loss, broad bandwidth and small diameter. At present, two possible windows in the optical fibre spectrum are expected for submarine system applications. They are located at 1.3 and 1.5 μm, where low loss can be achieved, leading to a potential repeater spacing in the order of 50 km.

Considerable research and development work is currently being applied to submarine optical fibre cable systems, because the following major advantages are now being expected on submarine optical fibre cable systems:

a) comparative cost studies show that optical fibre systems will offer a lower cost per circuit than metallic cable systems;

b) submarine optical fibre cable systems will almost certainly be digital and will meet the increasing demand for digital transmission and switching;

c) a modular capacity system can be achieved by selecting the number of two-way digital lines incorporated using a single basic cable and repeater design, because several pairs of fibres can be incorporated into a cable and an equivalent number of regenerators provided in a repeater housing;

d) the capacity of optical fibre systems can easily be increased by a number of methods; for example, increasing the number of fibres, increasing the transmission bit rates, and introducing wavelength division multiplexing (WDM);

e) optical fibre systems have the possibility of easily branching off two-way digital lines in the sea so that each two-way digital line can go to different places. This configuration may offer some economic advantages.

3. Application fields

Submarine cable systems can be classified in several ways, according to system length, capacity and water depth. Actually, a specific system may be expressed by a combination of these classifications, according to actual situations; for example, a long-haul, large capacity, deep water system.

Application fields for submarine optical fibre cable systems can be divided into a repeatered system and non-repeatered system.

A repeatered system will be widely applied to various routes from a short-haul to long-haul transoceanic route. Reliability is the most important subject in the repeatered system. The more the number of repeaters increases, the more rigorous the reliability requirements on each repeater become. The reliability is, therefore, the most challenging aspect in long-haul systems.

Submarine optical cable systems, which use a combination of low-loss fibres and laser diode operating at 1.3 or 1.5 μm, can offer a possibility of long non-repeatered systems with large capacity. Especially, the potential of 50 km or longer non-repeatered systems can be anticipated using a low-loss fibre operating at 1.5 μm and a low transmission bit rate. The capacity of the system can be increased by increasing the number of fibres incorporated into a cable. These non-repeatered systems can be used to cross channels, to connect islands and to link various marine stations such as oil rigs at sea. In a non-repeatered system, cables are the only undersea equipment and all other transmission equipments are installed on land. Therefore, reliability requirements will be significantly reduced. Moreover, according to demand or technology improvements in the future, the system capacity can be easily increased, without changing the submarine cable, by increasing transmission bit rate or introducing wavelength division multiplexing.

4. Targets and problems to be solved

Submarine optical fibre cable systems, compared to inland systems, must satisfy very severe requirements concerning reliability in a harsh environment and laying or recovery work by cable ship. There are still many problems to be solved in realizing a commercial system. These include:

a) realization of high repeater reliability;

b) designing a repeater housing and fibre cable whose characteristics will not change significantly on the ocean seabed, and

c) establishing a fibre and cable splicing method, and suitable equipment for use on a cable ship.

Considerable research and development work is currently being carried out to overcome those problems. Table 1 shows submarine optical fibre cable system targets for several countries. [1, 3-6, 8]

4.1 System design

Transmission speed is determined by market requirements for system capacity, the available technology, and the digital hierarchy for each country. Current transmission speed targets are up to 400 Mbit/s per two-way digital line.

A single transverse mode at 1.3 or 1.5 μm wavelength has been chosen in most countries to increase the repeater spacing by taking advantage of very low loss fibre characteristics. However, in present considerations for submarine optical fibre cable, 1.3 μm wavelength is usually selected. This is because fibre having both low loss and broad bandwidth at 1.5 μm is not available at present, and the reliability of 1.5 μm laser diodes is not yet certain.

A submarine optical fibre cable system should have a reliability of 8-15 years mean time between failures (MTBF). This is a formidable reliability requirement for a long-haul system. Therefore, the repeater spacing must be as long as possible. A consequence of longer spacing is that DC power feeding voltage and system cost may be decreased. Repeater spacing of about 25-50 km can now be expected, through the use of 1.3 μm laser diodes with a single transverse mode.

4.2 Cable

Submarine cables must have enough tensile strength (75-100 kN) withstanding tensile loading during laying and recovery. They must also be able to withstand very high hydrostatic pressure (up to 80 MPa) on the seabed over 20 years.

In optical fibre cables, fibre elongation during laying and recovery should be minimized in order to avoid fibre breakage and static fatigue problems. It is also considered necessary to provide the fibres with pressure-free and dry environments within the cable.

Table 1—Submarine optical fibre cable system targets

	country	United Kingdom	United States	France	Japan
system	transmission length	7500 km	8000 km	up to 10 000 km	1000-10 000 km
	water depth	7500 m	7500 m	more than 6500 m	8000 m
	transmission speed	140-280 Mbit/s	274 Mbit/s	140-280 Mbit/s	260-400 Mbit/s
	wavelength	1.3 µm	1.3 µm	1.3 µm eventually 1.55 µm	1.3 µm
	number of digital lines	1-5	3 max	1-4	2-3
	power supply current	1.2 A	1 A	1 A	1 A
	reliability (MTBF)	10 years	8 years	15 years	10 years
repeater	repeater span	25-50 km	25-50 km	25-50 km	25-50 km
	parts	monolithic ICs	monolithic ICs		monolithic ICs
	DC power consumption	3-5 W/fibre	4 W/fibre	5 W/fibre	3-5 W/fibre
	supervision	loop back	loop back	at least loop back	loop back
	LD redundancy	under study	3 standby max	3 standby max	0 or 1 standby
cable	optical loss	less than 1 dB/km	less than 1 dB/km	less than 1 dB/km	less than 1 dB/km
	tensile strength	90 kN	80 kN	80 kN	75-100 kN
housing		rigid housing	rigid housing	rigid housing (gimbal structure for burial)	gimbal structure

Figure 3 shows optical fibre cable structures now being developed in several countries, The goal is to have an attenuation of no more than 1 dB/km at 1.3 µm for fibre in an installed cable, and to have sufficient strength for laying and recovery at a maximum water depth of 8000 m for deep water cables.

The basic optical fibre cable structure is designed in the following manner:

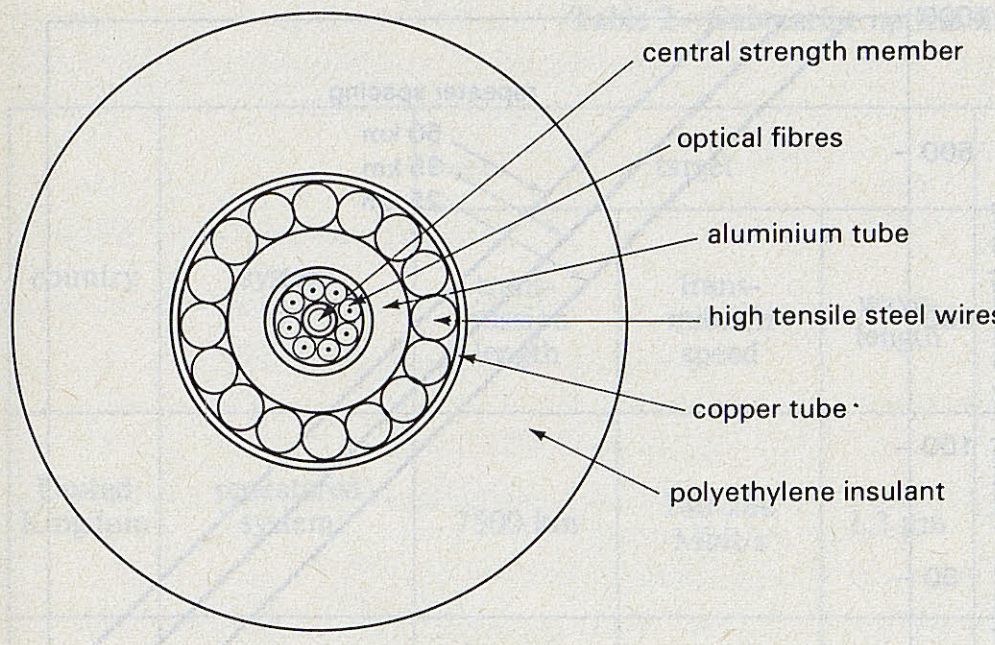
a) the fibres are housed in a thick-walled aluminium or copper tube and/or a carefully arranged high tensile steel strand wire structure that provides most of the pressure resistant capability for the cable structure;

b) an aluminium or copper hermetic tube is formed around the steel strand wire structure. This tube acts as a barrier to water vapour diffusion through the insulator;

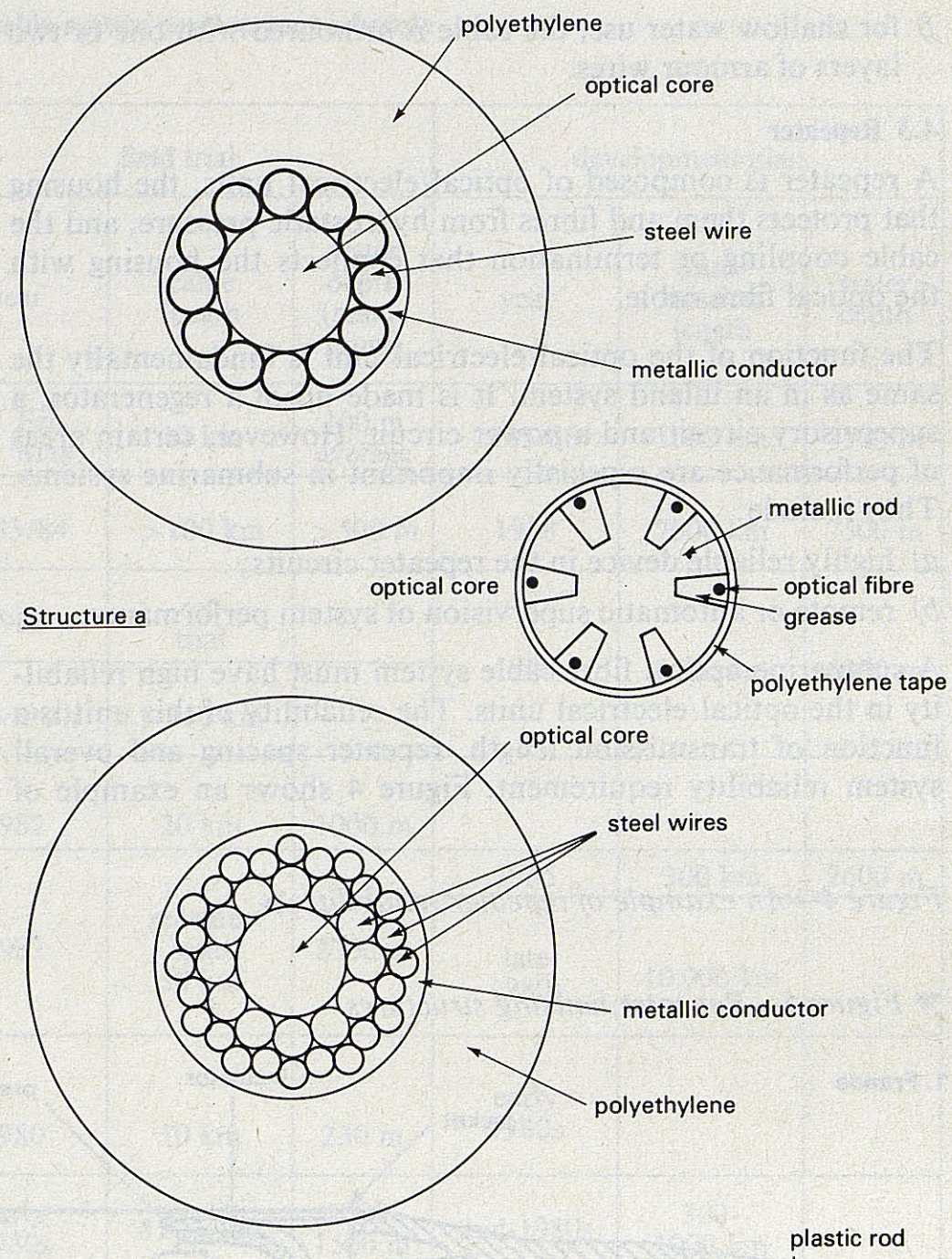
c) a composite conductor provides an electrical power feed path for repeaters;

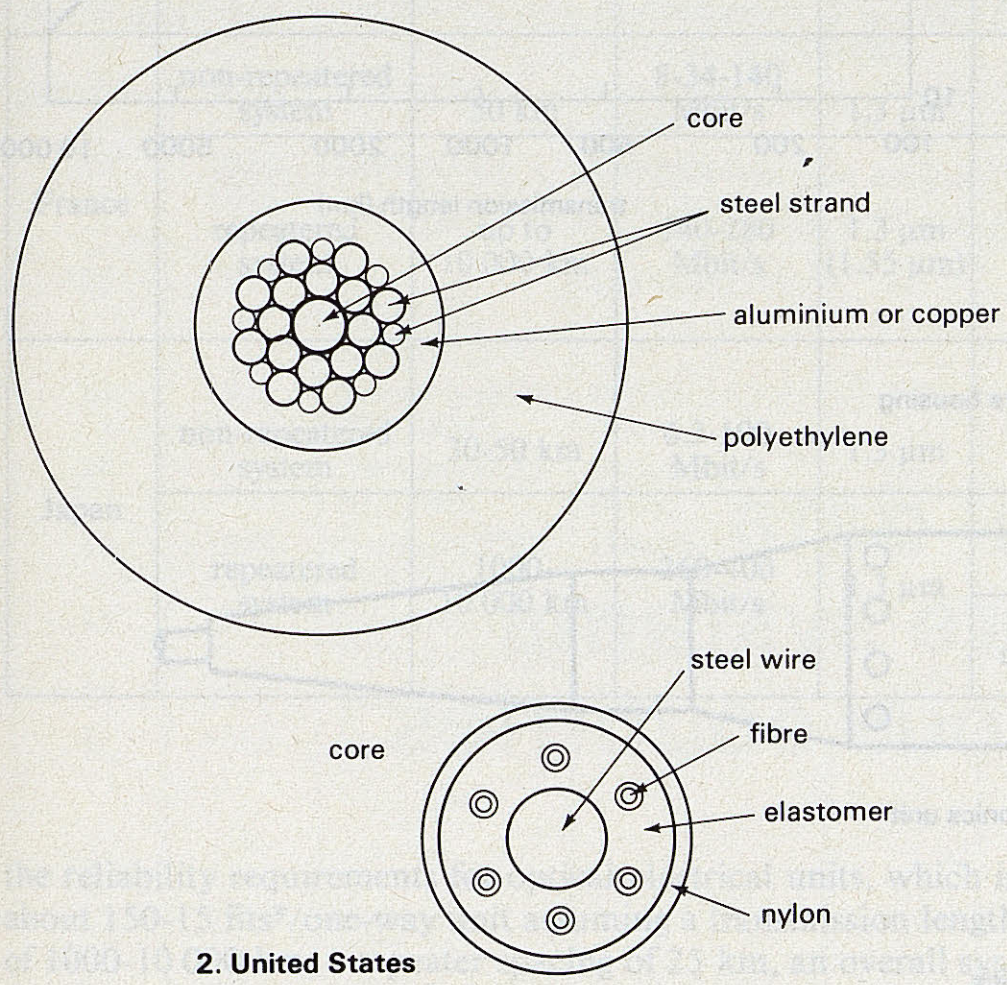
d) thick polyethylene insulates the composite conductor from the sea water (polyethylene thickness is chosen to give sufficient insulation for the seabed environment at the expected maximum terminal power feeding voltages);

e) a high density polyethylene jacket may be applied over the insulator to provide protection against abrasion;

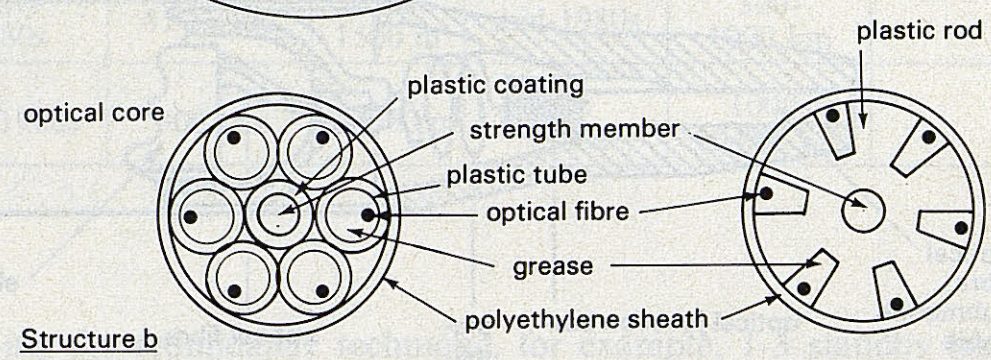


1. United Kingdom

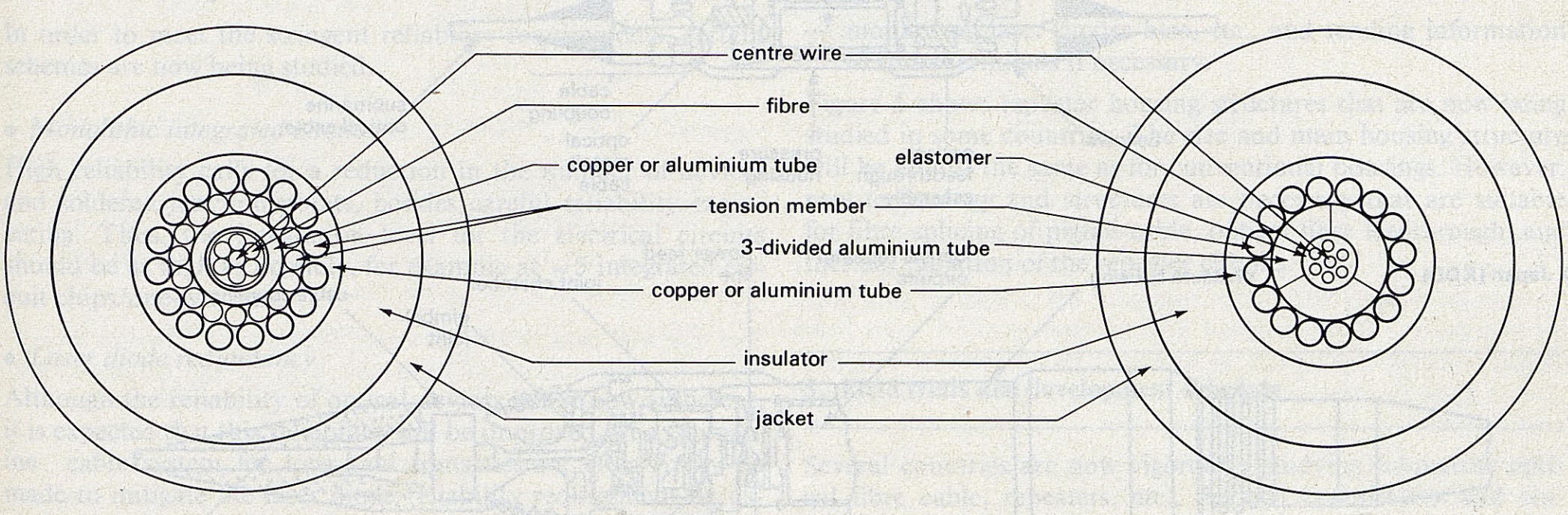




2. United States



3. France



4. Japan (NTT)

5. Japan (KDD)

Figure 3—Submarine optical fibre cable structures

f) for shallow water use, the cable is armoured with one or two layers of armour wires.

4.3 Repeater

A repeater is composed of optical/electrical units, the housing that protects them and fibres from hydrostatic pressure, and the cable coupling or termination that connects the housing with the optical fibre cable.

The function of the optical/electrical unit is fundamentally the same as in an inland system. It is made up of a regenerator, a supervisory circuit and a power circuit. However, certain areas of performance are especially important in submarine systems. They include:

a) highly reliable device in the repeater circuits;

b) remote or automatic supervision of system performance.

A submarine optical fibre cable system must have high reliability in the optical/electrical units. The reliability of this unit is a function of transmission length, repeater spacing and overall system reliability requirement. Figure 4 shows an example of

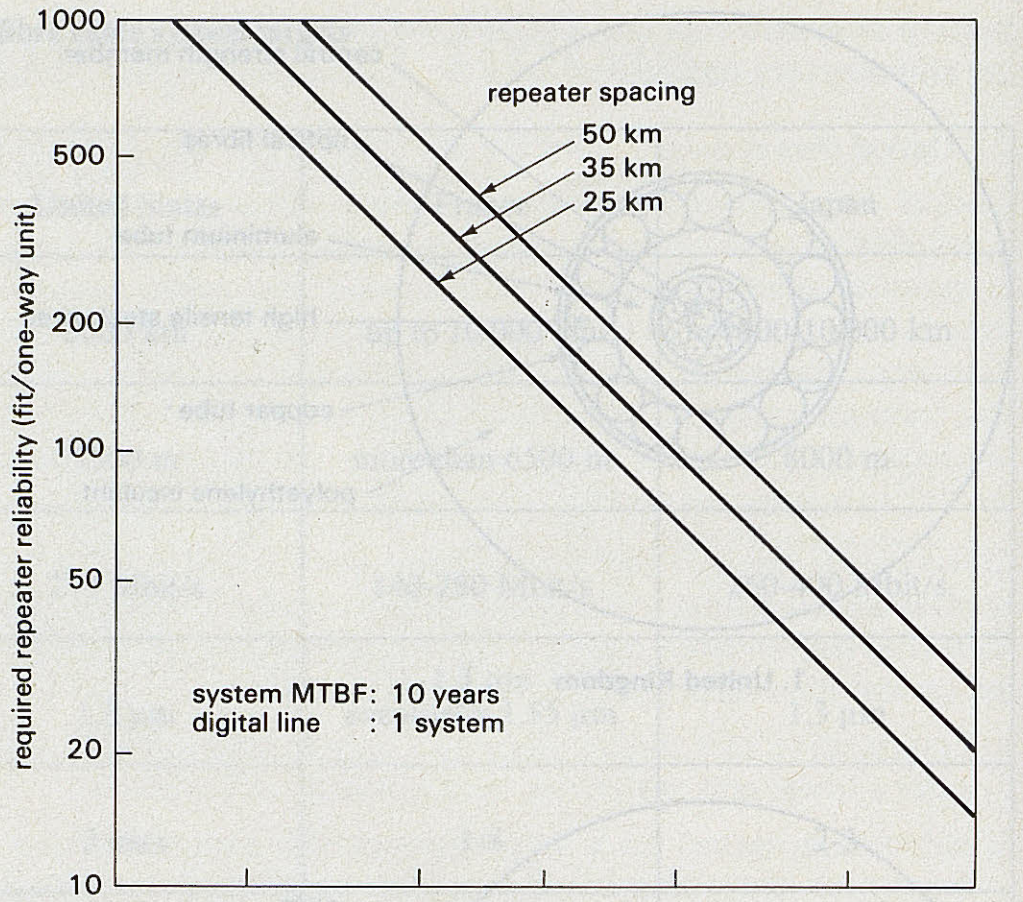


Figure 4—An example of repeater reliability ▶

▼ *Figure 5—Repeater housing structures*

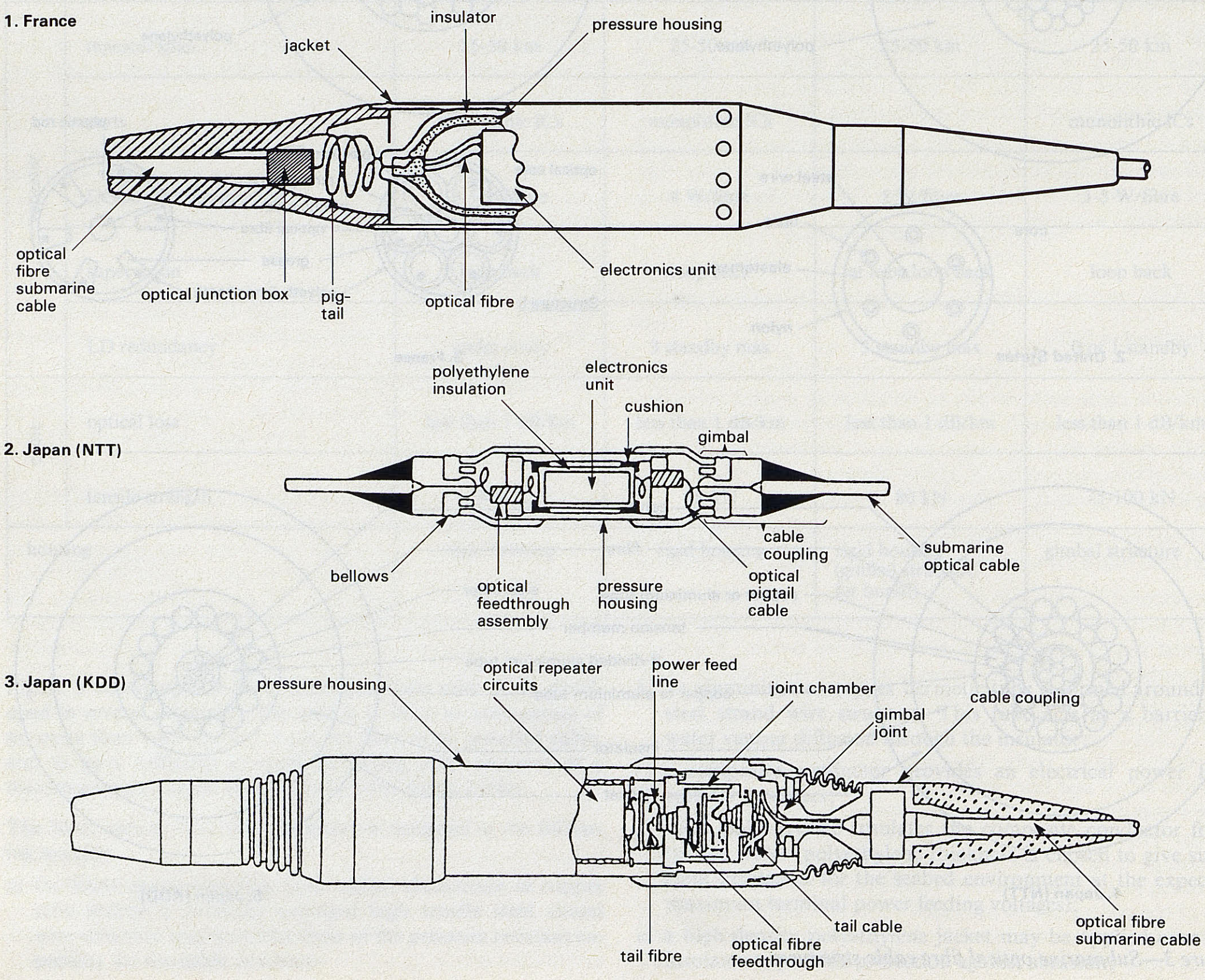


Table 2—Submarine optical fibre cable system development schedule

country	system	target			field trial			development plan		
		trans-mission length	trans-mission speed	wave-length	year	cable length	water depth (maxi-mum)	year	trans-mission length	water depth
United Kingdom	repeatered system	7500 km	140-280 Mbit/s	1.3 μm	1980 Feb. May	10 km	100 m average	1985/86	1000 km	7500 m
					1983/84	>100 km	>500 m	1988	7500 km	7500 m
United States	repeatered system	8000 km	274 Mbit/s	1.3 μm	1982	sea trial		1988	6500 km	6000 m
					mid-1980s	>250 km				
France	non-repeatered system	50 km	8-34-140 Mbit/s	1.3 μm	1982	20 km	1000 m			
	repeatered system	up to 10 000 km	140-280 Mbit/s	1.3 μm (1.55 μm)	1983	repeater span 30 km	2000 m	1985	300 km	2600 m
								late 1980s	10 000 km	
Japan	non-repeatered system	30-50 km	6.3-100 Mbit/s	1.3 μm	1980	10 km	230 m	early 1980s		
	repeatered system	1000-10 000 km	260-400 Mbit/s	1.3 μm	early 1980s	45-50 km	1000-1500 m	mid-1980s	300-1000 km	
					mid-1980s	300 km	>2000 m	late 1980s	1000-10 000 km	

the reliability requirements for optical/electrical units, which is about 150-15 fits*/one-way unit assuming a transmission length of 1000-10 000 km, a repeater spacing of 25 km, an overall system reliability of 10 years (MTBF) and single two-way digital line. Inland coaxial 400 Mbit/s repeater reliability is designed to be around 1300 fits/one-way unit,[9] and inland optical repeaters will be expected to have the same order of reliability.

In order to meet the stringent reliability requirements, certain schemes are now being studied.

• *Monolithic integrated circuits*

High reliability calls for a reduction in the number of devices and soldered junction points, besides careful reliability engineering. Thus, the integration level for the electrical circuits should be as high as possible, for example at ≈5 integrated circuit chips/one-way unit.

• *Laser diode redundancy*

Although the reliability of optical devices is not now sufficient, it is expected that this reliability will be improved. In a submarine cable system for long-haul transmission, efforts may be made to mitigate the laser diode reliability requirement by using the redundancy technique, for example, 1-3 standby laser diodes.

The supervisory circuit shall be capable of:

— localizing faults by a remote control loopback method;

— remote or automatic control of the switching circuit for laser diodes;

— monitoring laser diodes bias, etc., and sending information to shore terminals if necessary.

Figure 5 shows repeater housing structures that are now being studied in some countries. The size and main housing structure will be almost the same as for conventional housings. However, new technology and structures are necessary that are suitable for fibre splicing of pigtail cable, optical fibre feedthrough, and thermal radiation of the repeater circuits.

5. Field trials and development schedule

Several countries are now vigorously studying submarine optical fibre cable, repeaters, etc., through experiments and sea-trials, The fundamental technology has been progressing. For example, the United Kingdom laid a 10 km trial loop of cable in Loch Fyne, Scotland, in February 1980.[7] A 140 Mbit/s TDM/PCM both-way repeater was inserted into one pair of

* fit: *f*ailure un*it*

1 fit = 1 failure/(10^9 hour × number of components)

multimode fibres. Japan (NTT) installed a 10 km field trial cable along the Izu coast in October 1980.

Deep sea cable structure, monolithic integrated circuits and optical device reliability are now being looked at. It is expected that the development of optical fibre submarine cable systems will be carried out steadily, though the technological problems involved are severe. Commercial systems for non-repeatered short-haul routes, and repeatered medium-haul routes will most likely be installed in the mid-1980s. Repeatered long-haul systems will probably appear in the late 1980s. Table 2 outlines the development schedules for submarine optical fibre transmission systems in several countries.[1,3,4]

6. Conclusion

Several countries are actively developing submarine optical fibre cable systems, but there are still many problems to be solved before commercial use. The final goal of any organization is to realize a single mode transmission system, and especially a long-haul repeatered system. Major problem areas are the development of: highly reliable optical devices; high speed monolithic integrated circuits and low-loss high strength optical fibre cable. The first commercial submarine optical fibre cable systems are expected to be available in the mid/late 1980s after many field trials.

(Original language: English)

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Essential data on optical fibre systems installed in various countries

by

P. MATTHIJSSE
Dr. Neher Laboratories
Netherlands Postal and
Telecommunications Services
Leidschendam

1. Introduction

After the first field trials with optical fibre systems in the years 1975 and 1976 a steadily increasing number of systems have been installed throughout the world. At this moment more than 200 installed systems are reported, with link lengths varying from a few to hundreds of kilomètres. The nature of these systems is rapidly changing from experimental to commercial. Most of the latter are duplicates of earlier installed experimental systems, confirming the fact that optical fibre system technology comes up to expectations.

The systems presented in this article will be restricted to those reported to CCITT [1] and installed up to the end of 1981. Although this restriction implies that a number of systems are not included, especially short-distance and power plant systems, a sufficient impression of the present possibilities for telecommunications can be obtained. Submarine field trials are described in the article by Yamashita *et al* [1]

The essential data of the presented systems are listed in table I. These data and additional information on fibres, cables and systems are described briefly in the following sections. In this context it must be taken into account that data can depend heavily on the applied measuring methods (e.g. splice loss or receiver sensitivity) or on the nature of the installed system (e.g. the allowance of a zero system margin for an experimental system).

[1] This involves systems reported to CCITT Study Groups XV (Transmission systems) and XVIII (Digital networks) as well as those reported to the author in response to the request contained in COM XV-No. R1.

Table I—List of the essential data of the optical fibre systems installed up to the end of 1981*

system	year	country/ participant	location	link length	fibres	bit rate (Mbit/s)	source/ detector	longest repeater section (km)	application area	state of development	notes
1	1976	France/CNET	Lannion		19	34	LD/APD	8		E	
2	1976	USA/AT&T	Atlanta, GA	0.7	144	45	LD/APD		J	E	
3	1977	Canada/CTCA	Montreal	1.4	6	6.3	LED/PIN	4.5		E	
4	1977	France/CNET	Lannion			140	LD/APD	6		E	
5	1977	Germany (FR)/ PTT, Siemens	Berlin (West)	4.3	8	34	LED/APD	4.3	J	E	
6	1977	Italy/CSELT	Turin	4	3	34	LED/APD	5		E	
						34	LD/APD	10		E	
						140	LD/APD	10		E	
7	1977	UK/STC	Hitchin—Stevenage	9	3	8	LD/APD	9	J	E	
						140	LD/APD	3	T	E	1
8	1977	UK/BTRC	Martlesham—Ipswich	13	2	8	LED/APD (PIN)	6	J	E	
9	1977	UK/BTRC	Martlesham—Kesgrave	6	2	140	LD/APD	6	T	E	2
10	1977	USA/AT&T	Chicago, IL	2.6	24	45	LD/APD	2.6	L, J	C, E	
11	1977	USA/GTE	Long Beach—Artesia, CA	9	7	1.5	LED/APD	9		E	
12	1977	USA/ CENTEL, Valtec	Las Vegas, NV	4.5	6	45	LD/APD	4.5	L	C	
13	1978	Germany (FR)/ PTT, AEG	Berlin (West)	4.3	8	34	LD/APD	4.3	J	E	
14	1978	Germany (FR)/ PTT, SEL	Berlin (West)	4.3	8	34	LD/APD	4.3	J	E	
						34	LD/APD	8.6	J	E	
15	1978	Germany (FR)/ PTT, Siemens	Frankfurt	15.5	6	34	LED/APD	5.4	J	C	
16	1978	Germany (FR)/ PTT, TEKADE	Berlin (West)	4.3	6	34	LED/APD	4.3	J	E	
						34	LD/APD	8.6	J	E	
17	1978	Italy/CSELT	Turin	4	3	560	LD/APD	6		E	3
18	1978	Japan/NTT	Tokyo	21	48	32	LED/APD	6	J	E	
						32	LD/APD	12	J	E	
						100	LD/APD	10	J, T	E	
						4×1.5	LD/APD	14	L	E	4
						32	LD/APD	8	J	E	5
19	1978	Switzerland/ PTT	Bern	2.9	8	8	LD/PIN	2.9		E	
20	1978	UK/BT, PTL	Maidenhead—Slough	12.8	2	8	LED/APD	8.7	J	C, E	
21	1978	USA/GTE	Ft. Wayne, IN	4.3	6/10	45	LD/APD	4.5		C, E	6
22	1978	USA/ITT	Minnesota		3	1.5	LED/PIN	3		E	
23	1978	USA/Vista, NEC	Orlando, FL	8.7	10	45	LD/APD	5.1	J	C	
24	1979	Belgium/ RTT, GTE	Brussel/ Vilvoorde	10.5	7	34	LED/APD	4.2	J	E	
						140	LD/APD	5.3	J	E	
25	1979	Canada/BNR, BC, NT	Montreal	9	12	6.3	LD/APD	10.1		E	
26	1979	Canada/CTCA	Vancouver	7.2	2	45	LD/APD	7.4		E	7
27	1979	Canada/BNR, BC, NT	Weir, Quebec	3.7	8	—	LD/APD			C	
28	1979	China/PTT	Wuham		4	8	LD/APD	5.7		E	
29	1979	China/PTT	Beijing		4	8	LD/PIN	3.3		E	
30	1979	Denmark/ JTAS, NKT	Hørning—Stilling	5.1	6	34	LD/APD			E	
31	1979	Finland/ HTC, Nokia	Helsinki	1	4	2	LED/PIN		J	E	
32	1979	Finland/ PTT, Nokia	Hyvinkää	2.3	4	2	LED/APD		J	E	
						8	LED/APD		J	E	
33	1979	Germany (FR)/ PTT, Siemens	Berlin (West)	0.3/2.1	6/114	—	LED/PIN		L	C, E	8
34	1979	Italy/PTT, SIP, ITALTEL	Rome	16	18	34	LED/APD	8	J	C, E	
						140	LD/APD	8		C, E	

* Only the systems reported to the CCITT are listed.

system	year	country/ participant	location	link length	fibres	bit rate (Mbit/s)	source/ detector	longest repeater section (km)	application area	state of development	notes
35	1979	Korea (Rep.)/ MOC, KTRI	Seoul	2.3	4	45	LD/APD			E	
36	1979	Sweden/PTT Ericsson	Stockholm	6.5	6	34	LD/APD	6.5		E	6
						34	LD/APD	12		E	
37	1979	UK/BT, GEC	Uxbridge—Ruislip	6.1	3	8	LED/APD	6.1	J	E	
38	1979	USA/GTE	Tampa, FL	6.6	8	45	LD/APD			C	
39	1979	USA/GTE	Oil City, PA	5.7	4	45	LD/APD			C	
				4.2	4	45	LD/APD			C	
40	1979	USA/GTE	Honolulu, HI	4	10	45	LD/APD			C	
41	1979	USA/ITT	Pennsylvania		5	45	LD/APD	5		E	
42	1979	USA/AT&T	Trumbull, CT	6.4	12	45	LD/APD	6.4	L	C	
43	1979	USA/AT&T	Lake Placid, NY	4.1	12	6.3	LD/APD	4.1	L	C	
44	1979	USA/AT&T	Sacramento, CA	4.4	36	6.3	LED/PIN	4.4	J	C	
45	1979	USA/AT&T	Bernal Heights, CA	5.8	48	45	LD/APD	5.8	J	C	
46	1979	USA/AT&T, Harris	Phoenix, AZ	2.8	6	45	LD/APD	2.8	L	C	
47	1979	USA/ITT	Mansfield, PA	22	5	45	LD/APD	4	R	C	
48	1979	USA/ United Tel	Carlisle, PA	12	6	45	LD/APD	6	J	C	
49	1980	Austria/ PTT	Vienna	7	4	34	LED/APD	7	J	C	6
						34	LD/APD	7	J	C	
50	1980	Canada/CTCA	Alberta	50	12	274	LD/APD	3.2		E	
51	1980	Canada/BNR, BC, NT	St. Agatha—St. Adèle	20	12	6.3	LD/APD	10.6		E	
52	1980	Canada/BNR, BC, NT	Kitchener	8	12	45	LD/APD	8		E	
53	1980	Canada/BNR, BC, NT	Ottawa	12	24	45	LD/APD	6.8		E	
54	1980	Canada/BNR, BC, NT	Edmonton	8.2	4	—	LD/APD			C	7
55	1980	Canada/BNR, BC, NT	Berthierville, Quebec	10.8	12	1.5	LED/APD	10.8		E	
56	1980	France/PTT, Thomson-CSF	Paris	7.5	70	34	LD/APD	7.5	J	C, E	
57	1980	Germany (FR)/ PTT, TEKADE	Berlin (West)	0.4/0.9	2/216	.07	LED/PIN		L	C, E	
58	1980	Germany (FR)/ PTT, Siemens	Bavarian Alps	1.2/5.6	4	—	LED/PIN		R		8.9
59	1980	Germany (FR)/ PTT, SEL	Berlin (West)	.9/2.5	8/320	—	LED/PIN	—	L	C, E	10
60	1980	Germany (FR)/ PTT, AEG	Berlin (West)	.9/2.6	10/60	—	LD/PIN	—	L	C, E	11
61	1980	Germany (FR)/ PTT, AEG	Herford—Bünde	13	2	34	LD/APD	7.5	J	C	
62	1980	India/IP&T	Pune	4	6	8	LED/PIN	4	J	E	
63	1980	Italy/PTT, GTE, Telettra	Rome	16	18	140	LD/APD	8		C, E	12
64	1980	Japan/NTT	Kawasaki	18	24/48	6.3	LD/APD	12	L	E	
						32	LD/APD	10	J	E	
						32	LED/APD	9	J	E	13
						32	LD/APD	21	J	E	13
						100	LD/APD	9	J, T	E	
						100	LD/APD	18	J, T	E	13
						—	LD/APD	10	L	E	14
						—	LD/APD	20	L	E	13, 14
65	1980	Korea (Rep.)/ KEC	Pusan	1.2	4	6.3	LED/APD	1.2		E	
66	1980	The Netherlands/PTT, Philips	Eindhoven—Helmond	14.3	12	140	LD/APD	8.6	T	E	
67	1980	Spain/ CTNE	Madrid	.6	6	2	LED/APD		R	C, E	

system	year	country/ participant	location	link length	fibres	bit rate (Mbit/s)	source/ detector	longest repeater section (km)	application area	state of development	notes
68	1980	Sweden/ PTT, ITT	Stockholm	2	4	2	LD/APD	2		C	
69	1980	UK/BT, PTL	Brownshill— Wallsall	9	8	8	LED/APD	9	J	C	
70	1980	UK/BT	Gloucester— Walham	3	4	2	LED/PIN	3	J	C, E	6
71	1980	UK/BT	York—Haxby	5.5	4	2	LED/PIN	5.5	J	C, E	
72	1980	USA/AT&T	Atlanta, GA	11	36	45	LD/APD	6.4	J	C	
73	1980	USA/AT&T	New York, NY	3.7	24	.26	LED/APD	3.7	L	C	
74	1980	USA/Cont., NEC	Woodbridge, VA	7.2	6	45	LD/APD	7.2	J	C	
75	1980	USA/GTE	Everett, WA	9.5	10	45	LD/APD	9.5	J	C	
76	1980	USA/GTE	San Angelo, TX	4.6	10	45	LD/APD	4.6	J	C	
77	1980	USA/GTE	York, PA	8.4	8	45	LD/APD		J	C	
78	1980	USA/GTE	Sarasato, FL	10.1	8	45	LD/APD		J	C	
79	1980	USA/CENTEL, NEC	Humble, TX	8.6	14	90	LD/APD	8.6	J	C	
80	1981	Denmark/ P&T, LME, Philips, NKT	Aabenraa— Rødekro	7.9	6	34	LD/APD	7.9		C, E	15
81	1981	Denmark/ P&T, AEG, NKT	Copenhagen	2.6	8	140	LD/APD			C	15
82	1981	Denmark/ JTAS, NKT	Århus	5.1	8	34	LD/APD			C, E	
83	1981	Denmark/ KTAS, NKT	Copenhagen	3	8	34 34 140	LD/APD LED/APD LD/APD			C, E C, E C, E	
84	1981	Germany (FR)/ PTT, SEL	Stuttgart	14.2	4	34	LD/APD	7.3	J	C	
85	1981	Germany (FR)/ PTT, F&G	Nürnberg	12.2	2	34	LED/PIN	4.3	J	C	
86	1981	Japan/NTT	Hachioji	18	6	400	LD/APD	20	T	E	16
87	1981	Saudi Arabia/ PTT, Philips	Riyadh	5.4	6	34	LD/APD	5.5		C, E	
88	1981	Sweden/PTT	Stockholm	.5	8	—	LED/PIN	.5		E	17
89	1981	Sweden/PTT	Kristianstad	4	2	2	LED/PIN	4		C	
90	1981	UK/BT, STC	Aberyswyth— Ponterwyd	20	8	8	LD/APD	11	J	C	
91	1981	UK/BT, STC	Aberdeen— Kingswell	12	8	8	LD/APD	12	J	C	
92	1981	UK/BT, STC	Croydon— Vauxhall	15	8	8	LD/APD	8	J	C	
93	1981	UK/BT, STC	London— Vauxhall	3	8	8	LD/APD	3	J	C	
94	1981	UK/BT, PTL	Corris— Dolgellau	16	8	8	LED/APD	9	J	C	
95	1981	UK/BT, PTL	Corris— Tywyn	23	8	8	LED/APD	12	J	C	
96	1981	UK/BT, PTL	Corris— Machynlleth	9	8	8	LED/APD	9	J	C	
97	1981	UK/BT, GEC	London— Reading	74	8	140	LD/APD	8.3	T	C	
98	1981	UK/BT, GEC	Oxford— Reading	48	8	34	LD/APD	10	J, T	C	
99	1981	UK/BT, GEC	Banbury— Oxford	39	8	8	LED/APD	7.5	J	C	
100	1981	UK/BT, GEC	Arrington— Cambridge	17	8	8	LED/APD	7.5	J	C	
101	1981	USA/AT&T	Pittsburgh, PA	64	36	45	LD/APD	6.4	J	C	
102	1981	USA/AT&T	San Francisco, CA	14	144	45	LD/APD	6.4	J	C	

system	year	country/ participant	location	link length	fibres	bit rate (Mbit/s)	source/ detector	longest repeater section (km)	application area	state of development	notes
103	1981	USA/AT&T	White Plains, NY	48	72	45	LD/APD	6.3	J	C	
104	1981	USA/AT&T	Philadelphia, PA	27	96	45	LD/APD	6.6	J	C	
105	1981	USA/AT&T	Newark, NJ	42	72	45	LD/APD	7.1	J	C	
106	1981	USA/GTE	Hayward, WI	2.6	9	45	LD/APD	2.6	J	C	
107	1981	USA/GTE	Beaumont, CA	4.2	8	45	LD/APD	4.2	J	C	
108	1981	USA/GTE	Ozark, AL	1.4	6	45	LD/APD	1.4	J	C	

Notes:

1. 6.2 km also works.
2. Extended to 14 km.
3. Same cable as for system 6.
4. WDM system.
5. Also analogue 40 ± 25 MHz.
6. Two different cables.
7. Analogue, 70 MHz FM carrier.
8. PPM system.
9. 8 different cable plants.
10. 4 kHz, FM system.
11. 100 MHz, analogue system.
12. Two different systems on same cable as in system 34.
13. 1300 nm system.
14. PFM video transmission system.
15. Several systems on the same cable.
16. Single mode fibres, 1300 nm.
17. Analogue system.

Abbreviations:

C: commercially available
E: experimental
L: local network
R: rural network
J : junction network
T: trunk network

2. Fibres and cables

In the great majority of installed systems, multimode graded-index fibres are used. Concerning dimensions, only more recently installed cables contain the CCITT recommended 50/125 µm fibres. The specified attenuation coefficient of the fibre on reel varies from 3 to 6 dB/km in the wavelength region 800-900 nm. A trend towards the lower values of attenuation is noticeable for the more recently installed cables. Bandwidth values vary from 200 MHz × km to 1300 MHz × km, reflecting both the increase in production and in demand for different system bit rates. A histogram of the maximum theoretical numerical aperture of the graded-index fibres is given in figure 1, with respect both to the installed fibre length (figure 1 *a)*) and to the installed number of cable links (figure 1 *b)*). The loose tube cable structure is applied in about 50% of the systems; for the others, mainly the tight stranded and the tight ribbon structures are used.

Frequently the cables contain 4, 6 or 8 fibres. In the junction networks, cables containing many more fibres are also installed. Extreme values, 2 and 320, occur for cables in the local networks. Dimensions of the cables with 4-8 fibres vary from 7 to 25 mm with a mean value of about 10 mm. As a strength member, steel, fibre-reinforced plastic (FRP) and kevlar (aromatic polyamide) are applied.

The available data do not allow the determination of the influence of the cabling process on the attenuation and bandwidth of the fibres. Most figures are equal for the fibre on reel and the cabled fibre, or give design values only. The specified temperature dependence varies fron "no change" to less than 1 dB/km in the temperature range –30° to +60°C.

The weight per unit length depends heavily on the presence of armouring or metallic conductors. For unarmoured cables without metallic conductors this weight varies from 40 to 150 kg/km. If metallic conductors are present, the weight varies from 100 to 600 kg/km. For armoured cables the weight goes up to 1300 kg/km.

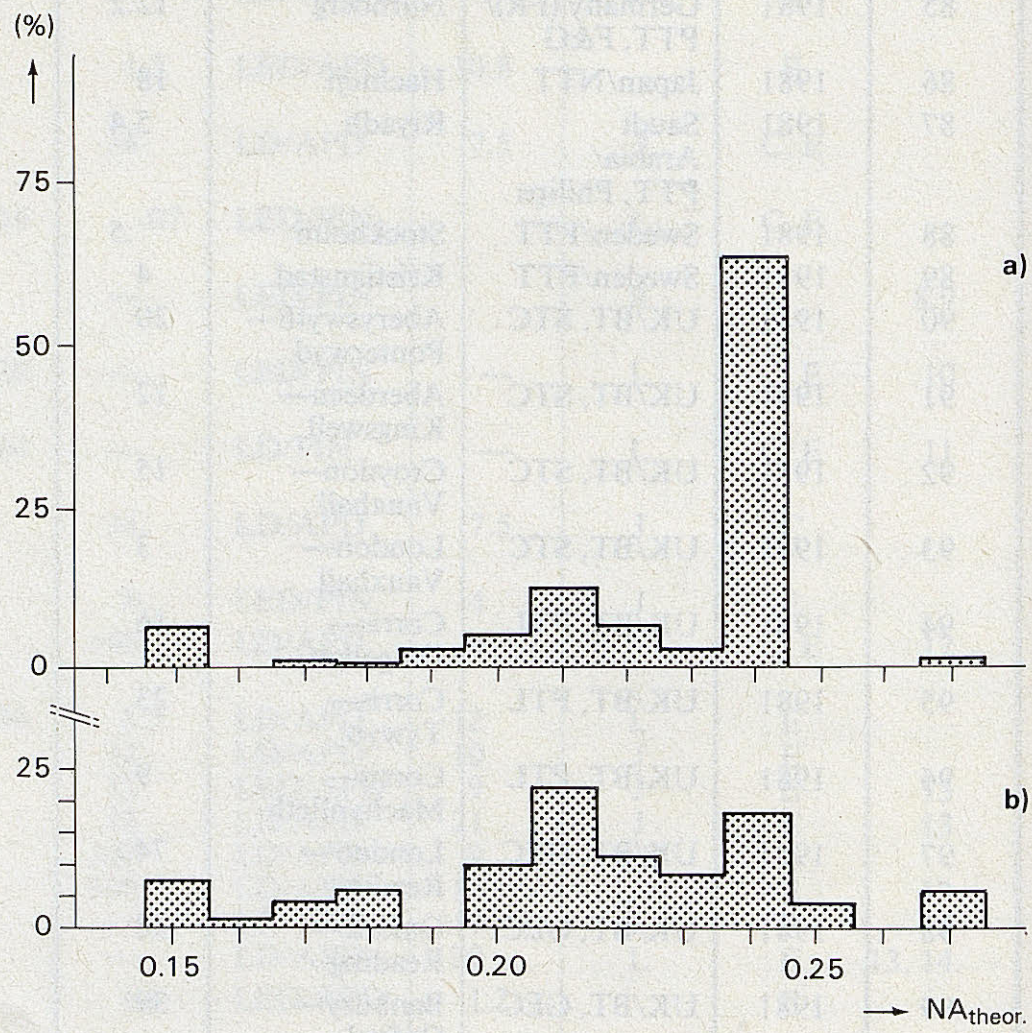

Figure 1—Numerical aperture (maximum theoretical value) histogram of:

a) *97% of the installed fibre length*

b) *94% of the installed number of cable links*

3. Installation and splicing

The maximum installation length depends on the type of installation used. For aerial installation, a maximum length of up to 3 km is used. For installation in ducts or in a trench, a common maximum installation length is about 1 km, independent of the weight of the cable. In some recent field trials in Japan and in France a maximum laying length in excess of 2 km is reported.

About 30% of the installed cables are pressurized while the remainder are either jelly-filled or unfilled. Splicing based on the electric arc fusion method is applied for more than 70% of the installed cables with numbers of fibres up to 48. The reported average loss values are distributed between 0.1 and 0.5 dB with a mean value of 0.3 dB. There is no noticeable trend towards lower values for the more recent installations. For the remaining cables, gas flame fusion, mass-splicing and mechanical splicing (collapsed tube, V-groove, 3-rod method) are applied. The average loss value varies from 0.1 to 0.8 dB; 0.3 and 0.4 dB are frequent occurring values. The influence of splicing on the total bandwidth is illustrated in figure 2. For a number of installed cable sections the attained average bandwidth B, relative to the average unit length (1 km) bandwidth B_0, is given. Assuming a length dependence

$$B \simeq B_0(L/L_0)^{-E}$$

where L is the fibre length and $L_0 = 1$ km, an indication for the E-value can be derived. For most sections a value between 0.5 and 0.7 has been obtained. Lower values also occur, showing the great influence on the bandwidth of mode coupling in fibres, splices and tolerances in the refractive-index profiles (equalization effects[2]).

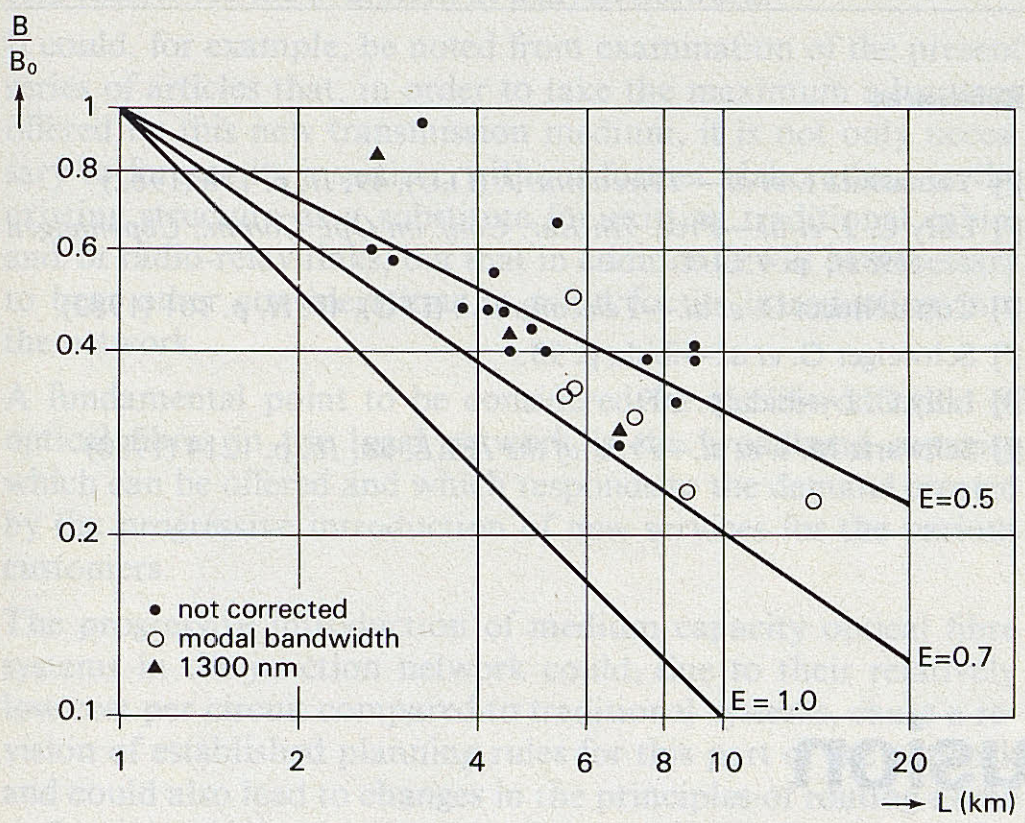

Figure 2—Average value of the bandwidth, relative to the unit fibre length bandwidth, of a number of installed fibre sections. For the data corresponding to the black dots, no correction for the influence of material dispersion could be carried out

4. Systems

In the preceding years, system development was mainly concentrated on 8-45 Mbit/s systems which involved more than 75% of all installed systems. Remaining systems have bit rates from 0.1 up to 560 Mbit/s whilst a number of analogue systems have been installed as well. Almost all systems work in the 800-900 nm wavelength region.

In table II two essential system parameters, the launched power and the receiver sensitivity, are given for a number of most frequently occurring digital system configurations. It will be apparent that generally the installed section lengths do not have the maximum achievable length. In more recently installed systems also, receivers applying p-i-n structure photodiodes (PIN) frequently occur. The sensitivity varies from about –53 dBm at 8 Mbit/s to –58 dBm at 2 Mbit/s.

The great majority of the systems are intended for application in the junction network, with link lengths varying from 1 to 64 km and bit rates up to 140 Mbit/s. For the local and rural networks there are a variety of system configurations, whereas especially high bit rate systems with laser diodes and avalanche photodiodes (LD/APD) are applied for the trunk network. Typical systems for each of these networks are described in three other articles in this issue.[3-5]

Table II—Range of values (minimum/maximum) of some essential parameters of digital optical system working in the 800-900 nm wavelength*

bit rate (Mbit/s)	6-8		32-34		45	140
source/detector	LED/APD	LD/APD	LED/APD	LD/APD	LD/APD	LD/APD
portion of total number of systems (%)	9	8	8	17	27	10
launched power (mean value, dBm)	–12/–6.5	–7/–5	–20/–15	–10/0	–5/–3	–6/0
receiver sensitivity (dBm)	–60/–45	–63/–51	–57/–41	–57/–41	–54/–51	–48/–40
installed section length (km)	1.2/12	3/12	3/9	4/12	1/10	3/14

* Only the system configurations contributing more than 5% to the total number of systems are given.

5. Conclusion

The systems presented in table I give a good indication of the state of development of optical fibre telecommunication systems. Due to the time-lag between the moment of realizing a laboratory system and the date that the developed commercial systems are functional there will be a difference from the optical system potentials described in the four previously mentioned articles.

In particular, the application of long wavelength components, single mode fibres and the introduction of optical fibre systems into the local area will change the image in the coming years. In the longer wavelength region the achievable section lengths will increase considerably. The Japanese field trial (see table I) with a section length of 20 km at a bit rate of 400 Mbit/s applying single mode fibres gives a good indication of these future possibilities.

The introduction of optical fibre systems in future networks does not only depend on the technical results of system installation, however. Operational aspects such as cable handling, splicing and cable damage are very important too. Although these aspects are not shown in the table, most experiences are rather positive. Handling of optical cables seems to be no more difficult than that of conventional copper cables. Although fibre breaks during installation did occur,[2] mostly due to errors, there is no reason for concern. Splicing can be done by the same personnel familiar with conventional splicing techniques without extensive further training.

Of primary importance for future operational use is the stability of the system performance. This is closely related to the stability of the received optical signal. Signal level variations may occur due to changes in the transmitter or in the transmission path. In the transmitter, the output power and the spectral characteristics of the optical signal can vary due to aging, replacement or temperature changes. In the transmission path the attenuation and bandwidth can vary due, for example, to wavelength changes, temperature changes and repair splices. To what extent these latter splices will be necessary as a result of long-term effects, e.g. crack growth, is the subject of many current investigations. In the case of coherent sources, modal noise can occasionally lead to bursts of unacceptable high bit error rate values. To ensure that the performance of future systems will not be restricted by one or more of these effects it will be necessary that more data become available.

(Original language: English)

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[3] Cottatellucci O. *et al.*—*Telecomm. J.* (ITU), **49**, *II*, p. 101 (1982)

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[5] Lilly C. J.—ibid., p. 109

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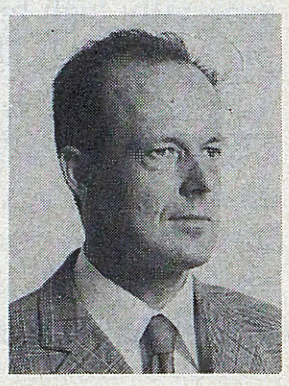
Conclusion



by
F. BIGI
CCITT Secretariat

and
G. BONAVENTURA
Azienda di Stato per i Servizi Telefonici
Ministry of Posts and Telecommunications
Italy

THE two special issues of the ITU *Telecommunication Journal* (November 1981 and the present one) have dealt with the utilization of optical fibres in all parts of the telecommunication network. Their publication has been made possible thanks to the co-ordinated work of the various authors and the subsequent harmonization carried out by an editing group in order to avoid duplication of work and to have only a given subject dealt with in one article.

The November 1981 special issue was mainly devoted to the analysis of the optical components needed to form an optical communication system. The articles of that issue, after having considered some basic principles and theoretical aspects, gave the present status of the technique and outlined possible trends leading to the establishment of complete optical communication systems in the future.

This special issue is of a more practical nature since it is devoted to possible applications of optical fibres to the various constituent parts of the telecommunication network. In particular, the various articles have examined the timing and the technical and economic aspects leading to the progressive introduction of optical fibres in the network.

A first general conclusion that can be drawn from the various articles is that the utilization of optical fibres could prove to be technically and economically feasible in all the different parts of a telecommunication network, namely the local and rural networks, the junction and trunk networks, including the submarine cable links. The timing of the introduction of optical fibres is more subject to national considerations, to priorities established and to differing planning schedules; it is also possible that their introduction could lead to some changes in the funda-

mental philosophy relating to the telecommunication network. It is however clear that optical fibres could facilitate the progressive introduction of new services in the network and could finally constitute a factor in the achievement of the future world-wide integrated services digital network (ISDN).

The work of standardization undertaken by the CCITT and by other international bodies, partly outlined in the various articles, for the different parts making up an optical fibre link (fibres, sources, connectors, detectors, measuring methods and apparatus, optical systems, etc.), could already give general guidance to adminstrations and recognized private operating agencies for the planning and the setting up of optical fibre systems.

The articles also deal with some aspects that could not normally be considered in the framework of international standardization, since they are more related to particular aspects and to solutions typical of a given national telecommunication network. These aspects are of fundamental importance to those responsible for the evolution of a given network.

It could, for example, be noted from examination of the present series of articles that, in order to take the maximum advantage offered by this new transmission medium, it is not only necessary to foresee its insertion, without further elaboration, in the existing structure as a substitute for existing traditional cables and/or radio-relay links, but that in addition it will be necessary to bear other considerations in mind for its introduction into the network.

A fundamental point to be considered for the introduction of optical fibres in the local network is the broadband capacity which can be offered and which responds to the demand created by the progressive introduction of new services for the various customers.

The progressive introduction of medium capacity optical fibre systems in the junction network could, due to their relatively low cost per circuit compared to traditional systems, cause a revision of established planning rules for this part of the network and could also lead to changes in the principles of routing of the various circuits in order to take the maximum advantage of the utilization of the different network facilities.

The introduction of optical fibre systems in the trunk network could cause a real revolution, due to their very high potential capacity for transmission, linked to the large bandwidth available, in particular for the systems using monomode fibres.

The introduction of optical fibres in the sector of submarine cables which can be considered as constituting part of a trunk network is more than promising; in fact, the longer repeater spacing which can be achieved with optical fibres will be particularly advantageous in submarine systems. However, in this case also it may be necessary to review traditional planning rules, since the possibility of having more than one fibre in a submarine cable allows different branching options and the division of the various fibres in a submarine cable between the different terminals.

The introduction of new modulation schemes, such as wavelength division multiplexing (WDM) would permit an increase in the capacity of systems in all parts of the network. However, more detailed network studies are necessary in order to assess for each particular situation the real advantages of using systems having such huge capacity, taking into consideration the related availability objectives and the need to provide alternative routing and spare facilities.

For all kinds of applications in the telecommunication network it has to be taken into account that while, for traditional coaxial cable systems, it was possible to rely on a given value of the transmission characteristics (e.g. attenuation), in the case of optical fibre cables the transmission characteristics are specified in ranges and this will lead to new rules for the planning and installation of optical fibres. In particular, it will be necessary to allow some margins in order to take into account possible modification of the transmission characteristics and/or of the optical components due to the effects of aging, the need for eventual repairs and the possible future introduction of systems having a larger capacity. For example, the introduction of the WDM technique will require some optical power in the couplers, and this has to be considered in the total power needed in the initial planning of optical systems.

However, it is clear that time, and experience gained in the various countries, will give a positive reply to these questions, thus allowing a better definition of the problems linked with the introduction of optical fibres in the different parts of existing networks. The information contained in the articles of the two special issues of the "Telecommunication Journal" already gives some indication in this respect and constitutes guidelines that are not generally considered as a part of the normal work of standardization. CCITT Study Group XV has agreed to revise the text of the various articles during the period 1981-1984 in order to take into account the latest developments in the technique and to ensure an internationally agreed text. It is hoped that the final text, which will be printed as a CCITT booklet, will constitute a valid guide for those involved in planning and responsible for the progressive introduction of optical fibre systems in the world-wide telecommunication network.

(Original language: English)

Special numbers on fibre optics—Order form

I wish to order:

— the special number on **Optical components** (November 1981).
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News

Establishment of a high-level course in "telematics"

☐ The *Ecole nationale supérieure des télécommunications* (ENST) and the *Ecole supérieure d'électricité* (ESE) in France have combined to establish a high-level course entitled "Telematics, information systems, communications networks".

The purpose is to provide top management engineers and company directors with very broad high-level training in all features of telematics, i.e. the technical aspects, with the very latest state of the art in data processing, telecommunications, network design and installation, the economic and sociological aspects with a study of the various effects of telematics on the activities of the undertaking, and the political aspects, comparing the points of view of all the interests involved.

The course, the first session of which will be held from February to December 1982, comprises 38 half-day modules arranged in blocks of one to two days every two weeks.

The standard of the lecturers in on a par with the ambitions of the programme: 28 important personalities assisted by over 120 experts are to participate in the course.

The contribution of telecommunications to data processing, the introduction of data processing in telecommunications and the establishment of communications networks may cause radical changes in the running of companies and administrations. The introduction of telematics in an enterprise poses many problems at the technical, economic and human level.

This part-time high-level course will greatly assist all those for whom, by virtue of their position in public or private enterprises or administrations, telematics will inevitably be playing an increasing role.

For further information write to: "ESE, Direction des études, Plateau du Moulon, F-91190 Gif-sur-Yvette". Tel.: (6) 941 80 40 or "ENST, Service de la formation continue, 46, rue Barrault, F-75634 Paris Cedex 13". Tel.: (1) 580 40 80. Telex: 200914.

Bermuda telephones go digital

☐ Northern Telecom International Limited (Canada) and the Bermuda Telephone Company Limited have signed a nine million Canadian dollar contract to modernize the telecommunication network of the Atlantic resort island, changing from analogue to digital technology within two years.

Northern Telecom officials said it is the first time a national telecommunication network is being changed over from the traditional analogue to digital technology. When the changeover is complete only one computer-controlled electronic analogue switch will remain in the Bermuda network.

The contract calls for the installation of the equivalent of more than 22 000 lines.

The new equipment includes a *DMS-100/200* switch for combined local and long-distance operations, with a capacity of 6000 lines. Another 5800 lines will be provided by two remote modules. There is also a *DMS-100* local switch of 6000 lines and two more remote modules that provide and additional 4800 lines.

The system also includes 20 computer-based positions for telephone operators, to help them handle long-distance calls with greater efficiency.

The switches and remote modules will be located at six sites throughout the island and will be linked by digital transmission systems supplied by the Canadian company.—*Northern Telecom.*

Telephone/telex combiners for Ireland

☐ The Irish Department of Posts and Telegraphs has ordered from Telectron Limited 1100 telephone and telex combiners.

These units will allow the administration to use its existing telephone subscriber lines simultaneously for both telex and telephone services.

The system operates by slightly reducing the bandwidth of the telephone circuit to 2.7 kHz and uses the remainder of the spectrum (to 3.4 kHz) to provide a normal duplex 50 baud telegraphy circuit.—*Telectron.*

Digital switching for Switzerland

☐ Switzerland is to introduce digital electronic switching to handle its long-distance calls. The Swiss PTT has placed an order with *Siemens-Albis* for an *EWSD* exchange for intercontinental telephone traffic. The exchange is to be built in Zurich-Herdern, with commissioning scheduled for the end of 1983. Expansion of the exchange from its initial installed capacity of 2400 lines up to 16 000 lines is planned for the future.

With this order from the Swiss PTT, Siemens has to date received orders for the digital public switching system EWSD from the following ten countries: Argentina, Austria, Egypt, Federal Republic of Germany, Finland, Greece, Libya, Philippines, South Africa, and Switzerland.—*Siemens.*

Saudi order for switching equipment

☐ Saudi Arabia has made substantial extensions to its existing orders with *LM Ericsson* and *Philips* for its giant telephone expansion project. The new orders include 14 000 lines of *AXE* and 27 000 lines of *PRX* digital switching equipment for new local exchanges, and extensions of existing local and transit exchanges, as well as over 50 000 telephone instruments of Ericsson's *Diavox* type. Substantial orders for outside plant are also included.

The total value of the orders now received by the Philips and LM Ericsson joint venture in Saudi Arabia is around 200 million US dollars.

Orders received by Ericsson and Philips in Saudi Arabia during the past four years within the framework of the country's telephone expansion project now total over 4 milliard US dollars.—*LM Ericsson.*

United Kingdom exchange orders

☐ Orders to the value of 600 million pounds sterling (GBP) are planned with three United Kingdom manufacturers, British Telecom has announced.

The proposed spending, over the three years 1982-1985, will be for 190 *TXE4A* exchanges and 54 extensions to existing exchanges. These will be installed in towns and cities throughout the country, including London, Manchester, Liverpool, Leeds, Brighton, Belfast, York, Reading, Colchester, Taunton, Nottingham and Norwich.

The three companies which will benefit from the orders are Standard Telephones and Cables Limited, Plessey and GEC. These companies have already received orders for TXE4A exchanges worth 225 million GBP.—*British Telecom.*

INMARSAT backs satellite research

☐ A research and development programme devoted to improving maritime satellite communications and identifying new uses for them is being funded by the International Maritime Satellite Organization. 1.5 million US dollars (USD) have been earmarked for the project in 1982.

INMARSAT is the 36-nation body set up to establish a global maritime satellite communications system for ships and off-shore rigs. The new system will come into operation on 1 February 1982, taking over from the existing US-owned MARISAT system.

INMARSAT will support research and development in areas that promise to:

— improve the efficiency of maritime satellite communications;

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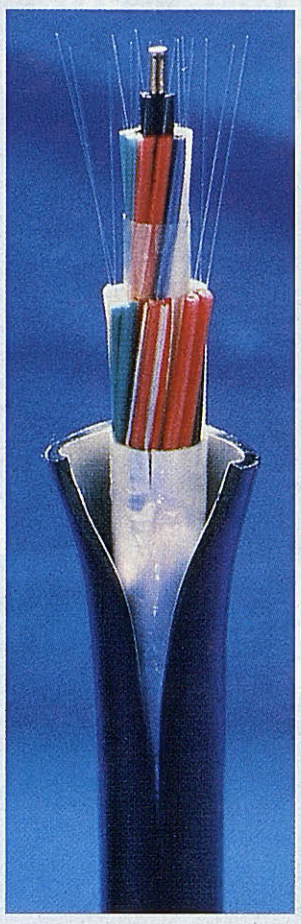
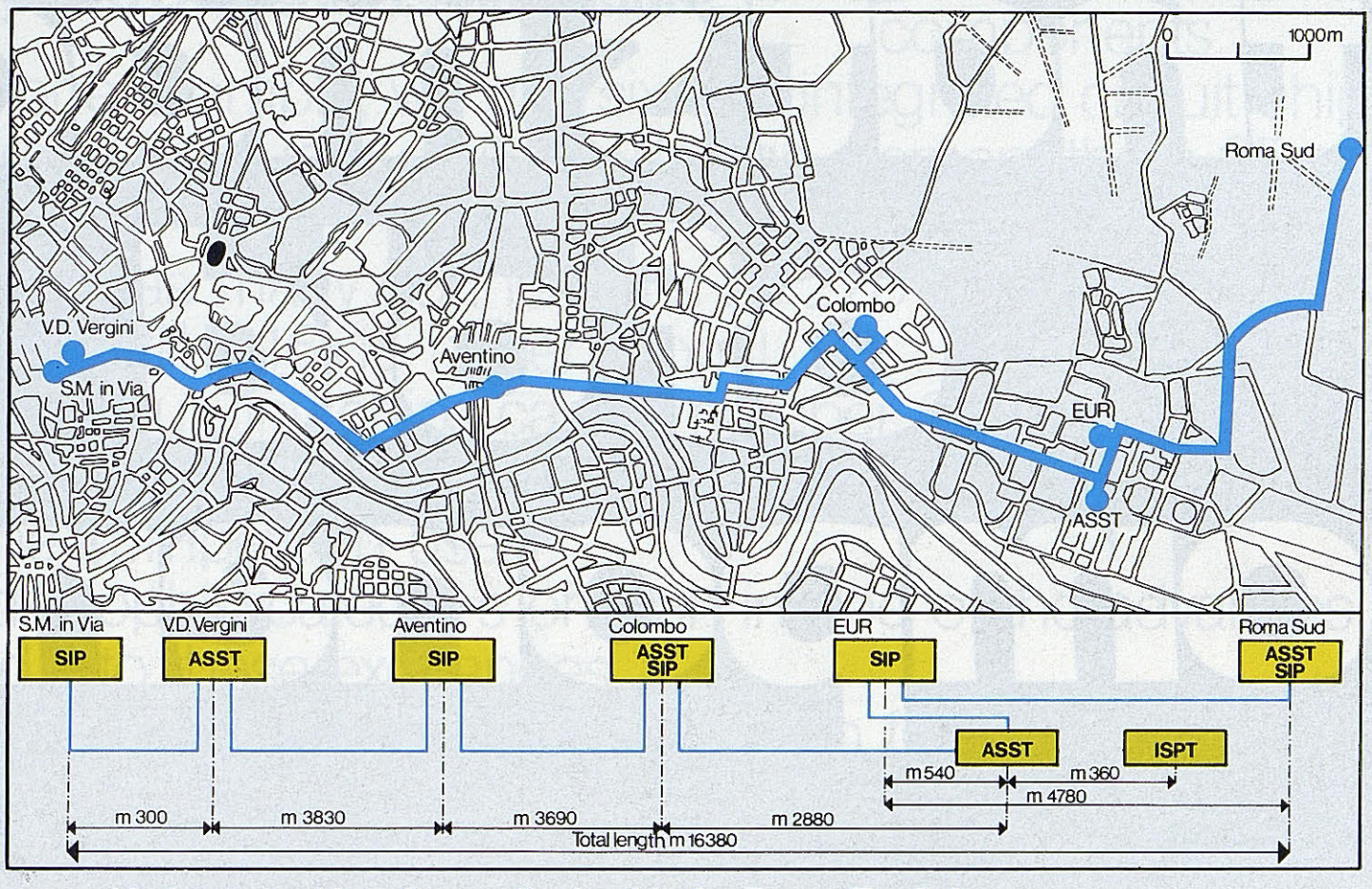
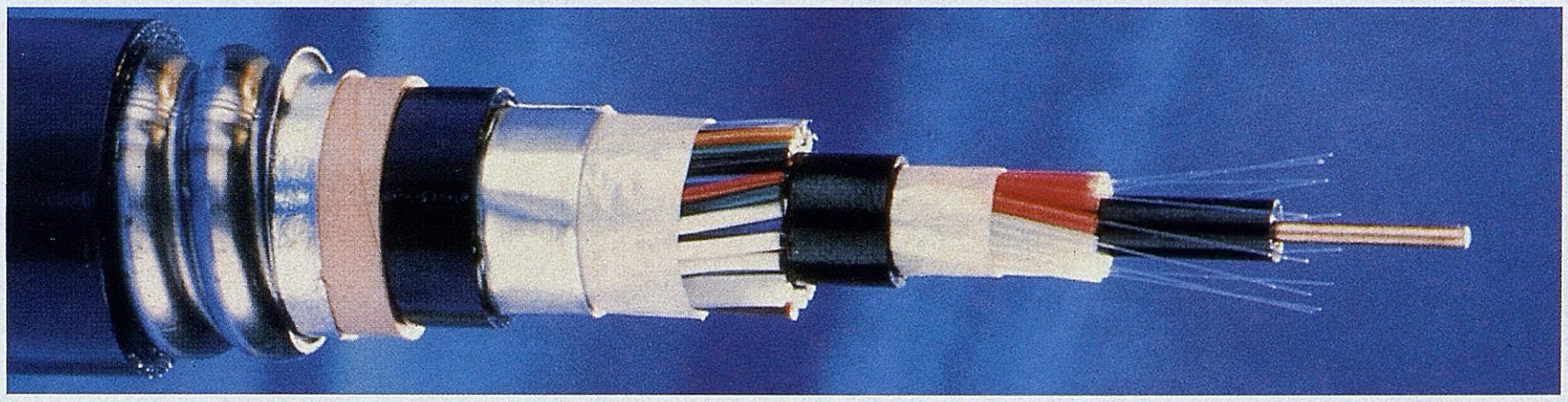




Underground junction optical cable for Roma-Eur link



Underground long distance optical cable for Padova-Mestre link

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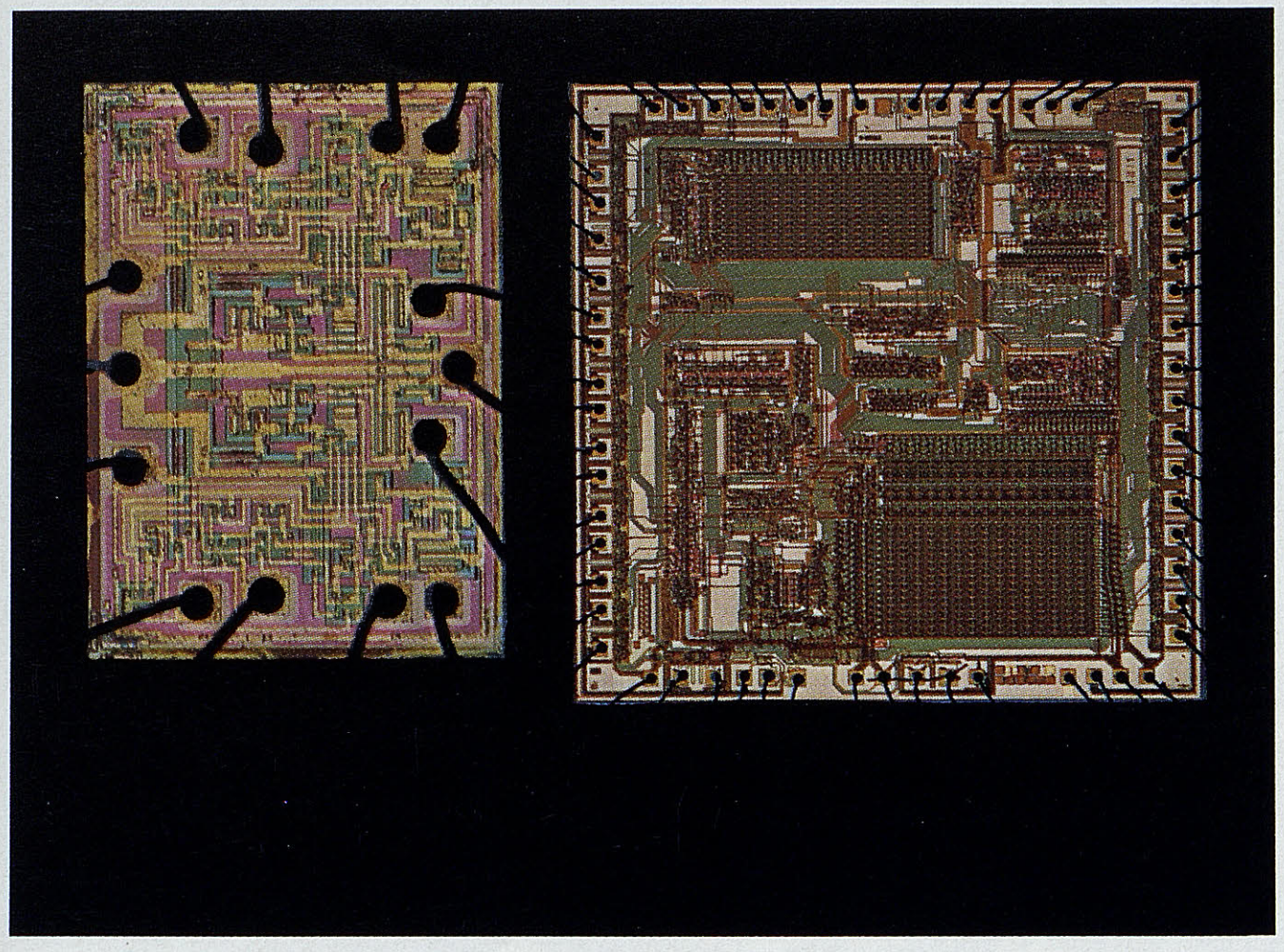
How new can a telephone system be that's made of old components?

In many countries today, telephone authorities are looking at new telephone exchanges.

And understandably, they want the latest, most sophisticated technology.



Both are chips, but the similarity ends there. The System 12 chip (right) has 11,500 transistors with circuitry on a chip only 5.9mm square.

What many countries are learning, though, is that not every telephone exchange that parades as "new" really is new.

And a good test is the components the exchange is built with.

Now in the case of ITT's new System 12,™ we've incorporated a lot of new technology—much of it radically new—in architecture and components.

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Which makes System 12 and its unique technology well worth a special look.

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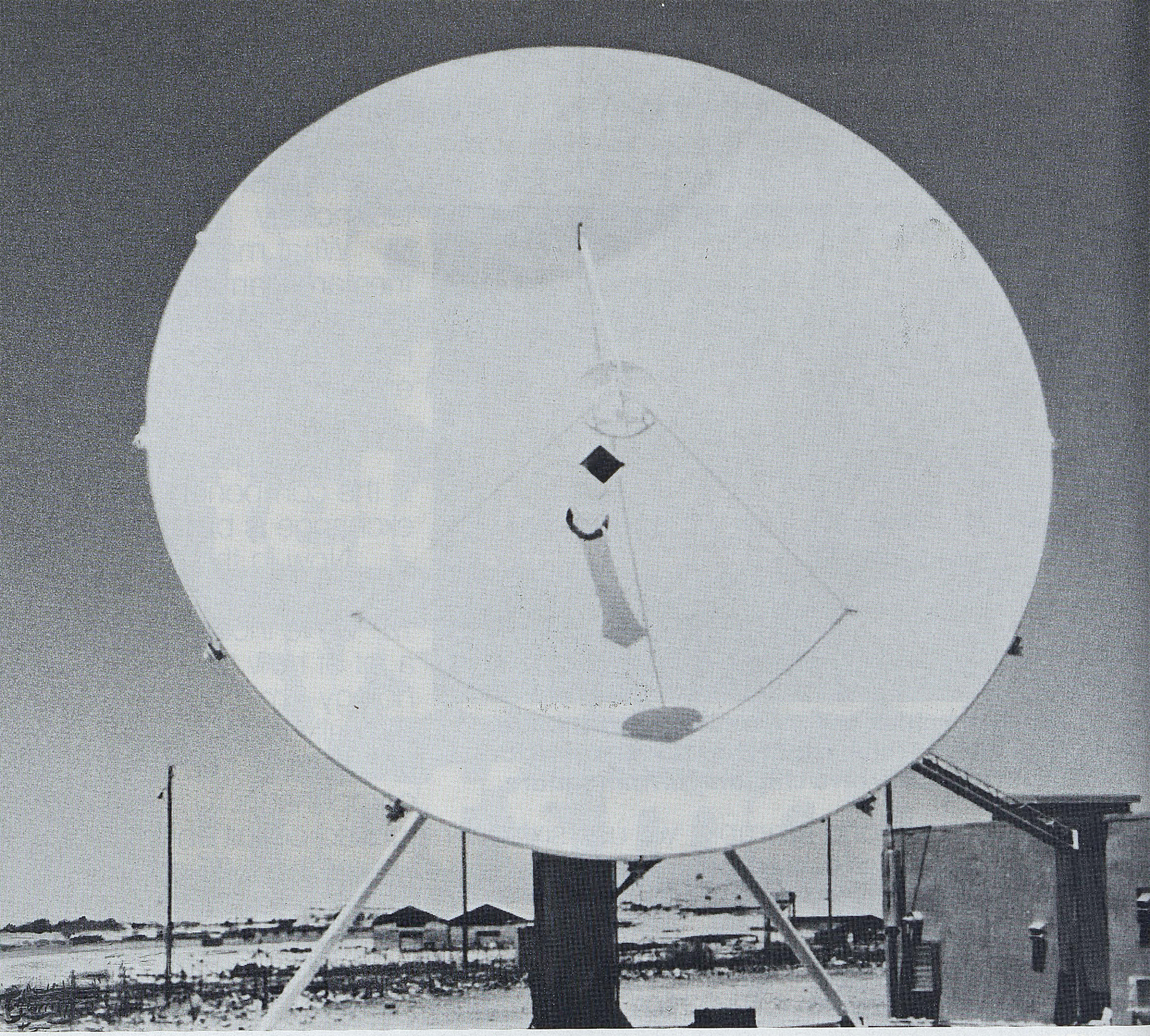

Who's bringing telephones and television to people in the Sahara...

GTE, the worldwide communications people.

More than 90% of Algeria is desert, with towns as much as 1600 km apart. But the Sahara is home for a half-million Algerians, and the government wanted to bring them both telephone and television.

A study concluded that a satellite communications system would cost about a third as much as a microwave system. GTE International Systems Corp. was selected to design and install the system.

The network comprises a master station near Algiers and earth stations at 14 other Algerian cities. The success of this pioneering service has led to a dramatic increase in satellite communications for intracountry use.

Across the South Atlantic, other GTE products are at work for the Chilean telecommunications

and helps Cristina Velez call her mother in Santiago?

agency. These are three GTD-1000 computer-controlled digital switching systems. One, in the coastal city of Iquique in northern Chile, has been given the unusual assignment of switching toll calls from public telephones.

Another, in Santiago, is used for similar work. A third, below the Strait of Magellan on the desolate island of Tierra del Fuego, serves an oil company's private communications needs, linking all locations via both microwave and satellite.

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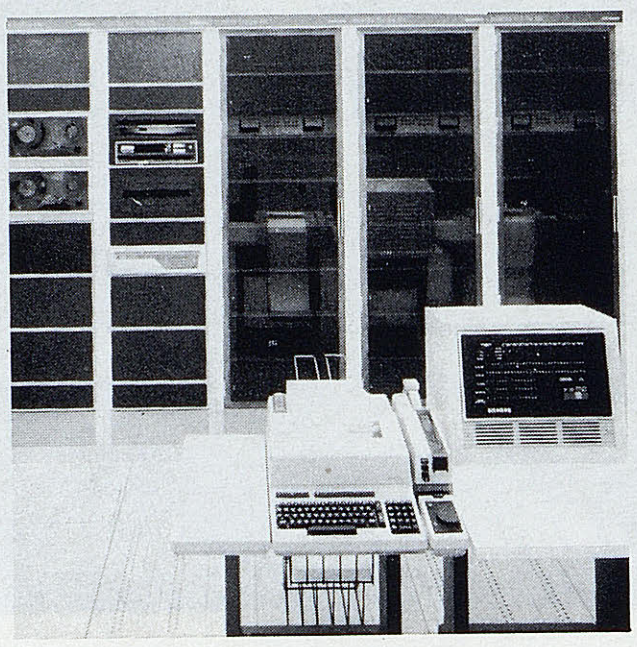

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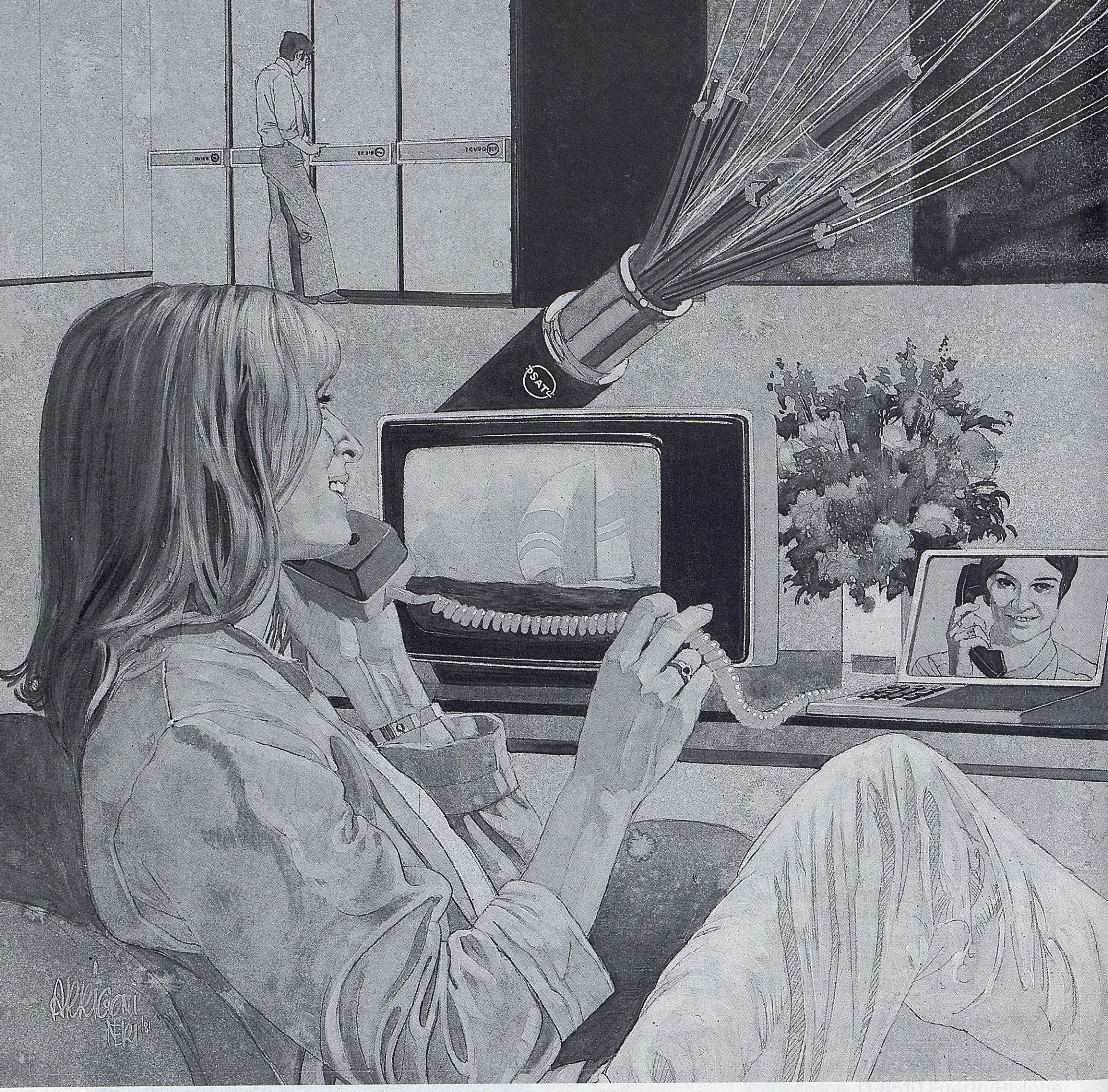

SAT'S WORLD "PREMIÈRE" IN BIARRITZ

6000 families are going to communicate by videophone

The French Ministry of Post, Telephone and Telecommunications has awarded SAT a contract to wire with fiber-optical cables the coastal city of Biarritz in the southwest of France*. The essential goal of this world premiere project is to provide local subscribers with videophones, an extensive selection of TV and high fidelity music programs as well as new telematics services.

The advantages of optical fibers, fine glass hairs over which laser rays are propagated, are manifold: insensitivity to electromagnetic interference, small diameter and light weight, high information-carrying capacity and ability to transmit speech, data and TV pictures simultaneously.

In addition to fiber-optical cables, SAT's system designers and technicians are exploring such high-technology sectors in electronics and telecommunications as infra-red applications, lasers, complex data multiplexing, image compression, telematics and office of the future applications.

Already, in each branch of telecommunications whether telephony, remote data processing, cable transmission, microwave radio systems or satellites, SAT is incorporating advanced techniques into reliable, easy-to-use and cost-effective products.

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Télex 250054 Telec Paris

* in cooperation with LTT

— reduce the cost of the space segment and the ship and coast earth stations;

— allow the introduction of new services;

— improve the distress and safety capabilities of the INMARSAT system;

— widen the coverage area of the INMARSAT system.

Part of the programme will be carried out by INMARSAT itself, while the remainder will be contracted out.

Key areas for study include extension of all new telecommunications services available on land to mobile users, specific features required to support a new and vastly improved distress and safety communications system, a new ship terminal standard for users requiring several channels (e.g. in the off-shore industry) and concepts for next-generation INMARSAT satellites.

The programme will also include the study of characteristics of a small ship earth station mainly for telex and low-speed data applications, suitable for very small ships. Such a terminal might also be of interest for other mobile uses such as on board aircraft.

In the context of the research and development programme, INMARSAT has decided to make space segment capacity available for experiments with communications for aircraft and land vehicles.—*INMARSAT.*

Auction of satellite transponder leases realizes over 90 million USD

☐ A total of 90.1 million US dollars (USD) was bid at a New York auction recently to obtain lease rights for seven transponders on the *Satcom-4* communications satellite of RCA American Communications, Inc.

Winnings bids for individual transponder leases ranged from 10.7 million to 14.4 million USD. RCA still has 17 transponders left for its own use on the satellite, which was launched from Cape Canaveral on 15 January 1982.—*RCA.*

Fibre optic video system for British Telecom

☐ A contract to provide British Telecom with fibre optic local ends for its experimental business visual services network has been awarded to Marconi Communication Systems Limited.

For many years a major problem inhibiting the introduction of visual services to the subscriber has been the difficulty of transmitting video signals on the local connection. Now Marconi Communication Systems has developed a fibre optic local end system comprising a combined transmitter and receiver operating over a pair of fibre optic cables to provide two-way visual communications using standard 625 line monochrome video.

British Telecom plans to establish a trial network, using compressed television on the trunk circuits, between London and several other major cities. At each city there will be one or more local video exchanges, giving users access both to other users on their own exchange, as well as to users on the local networks of the other cities involved. A selection of the local connections between customers' premises and the local exchanges will be on optical fibres using Marconi's new technology.—*Marconi.*

Report on fibre optics industry

☐ Decreasing prices, the resolution of technical problems, and the concerted efforts of industry groups for standardization are opening the door to rapid growth in the fibre optics market. International joint ventures, which are on the increase, will help open up fibre optic technology to new markets. At the same time, however, competitive requirements are intensifying and a shakeout is likely to occur, according to a market analysis released by Creative Strategies International (CSI), a world-wide market research and consulting firm.

By 1986, sales of cable, fibres, emitters, detectors, and connectors/couplers will reach 930 million US dollars (USD), reflecting a compound annual growth rate exceeding 45%. This is particularly impressive when considering the fact that prices of nearly every component will decrease at a rate of approximately 30% per year during the forecast period.

Although substantial growth will occur in all product segments, the greatest increase in revenues will come from cable. By the end of the forecast period, CSI expects cable to account for more than 50% of total industry revenues. A more detailed analysis reveals that both the single- and multi-fibre step-index segments will decrease as a percentage of the total cable market.

In the emitter market, long-wavelength LEDs and all types of semiconductor lasers will increase significantly as a percentage of emitter sales, but will lag far behind short-wave LEDs in total units sold.

Viewing the fibre optics market from a geographical perspective, CSI expects the relative sizes of the five segments—United States, Canada, Japan, Western Europe, and the rest of the world—to remain fairly steady. The fastest growing area, however, will be the less developed countries, whose fibre optic installations will grow at a rate of nearly 73% per year.

Additional insight into the fibre optics market can be obtained by analysing the industries that use fibre optics. Among these industries, telecommunications will maintain its position as the largest and one of the fastest growing markets. With a compound annual growth rate of over 50%, telecommunications will pick up an additional 6% of the total fibre optics market by 1986. Video communications will also see dramatic growth.

The report presents market forecasts up to 1986 in units and dollars by product segment, end-user industry, and geographical location. Each of the product segments is further analysed by specific component type.

The report, entitled *Fiber optics*, which sells for 1200 USD, also includes a competitive analysis and market strategies of major competitors and is available from "Creative Strategies International, 4340 Stevens Creek Blvd., Suite 275, San Jose, CA 95129 (United States)".—*CSI.*

In France: establishment of an optical fibre company

☐ With a view to continuing and expanding the development of optical fibres in France and founding, in accordance with the wishes of the French PTT Administration, an industrial centre capable of exporting on the international market, *Saint-Gobain* and *Thomson-CSF* have pooled their technical and industrial resources and have set up the *Fibres optiques industries* company, in association with Corning Glass Works.

The capital of Fibres optiques industries, amounting to 33 million French francs, is distributed as follows: 60% for the financing company for optical fibres (51% of which is held by *Quartz et Silice* and 49% by *Lignes télégraphiques et téléphoniques* (LTT)) and 40% for Corning Investment.

Fibres optiques industries has two industrial centres, one at Conflans-Sainte-Honorine (Yvelines) supplied by LTT, a branch of Thomson-CSF, and the other at Pithiviers (Loiret) supplied by Quartz et Silice, a branch of Saint-Gobain.—*Thomson-CSF.*

Videotex data bank research centre to be launched in Quebec

☐ Canadian Federal Communications Minister Francis Fox has signed an agreement with J. Bernard Lavigueur, President of the *Ecole polytechnique de Montréal*, and David Whiteside, President of Digital Equipment of Canada Limited, to establish a *Telidon* data bank research centre in Quebec.

Telidon is the videotex system invented by the federal Department of Communications (DOC).

By pooling their special resources, the three organizations intend to create a centre of excellence in videotex research. The federal Department of Communications will provide the Ecole polytechnique with a user terminal, a page-creation terminal, and engineering expertise to co-ordinate the project. This project will lead to creation of a data bank with 10 000 pages of textual and graphic information.

The objectives are to improve data banks and software programs, to identify new methods for organizing information retrieval, and to explore possibilities for tele-education and computer-aided design.—*DOC.*

Telematics: a Franco-Italian agreement

☐ On 9 November 1981, a protocol was signed between the *Direction générale des télécommunications* of the French PTT Ministry and the Italian holding company *Società Finanziaria Telefonica* (STET), the bulk of whose capital belongs to the State organization *Istituto per la Ricostruzione Industriale* (IRI). *Italtel SpA*, a branch of STET and the leading Italian manufacturer of telecommunication equipment, will be experimenting with the French videotex system for about one year as from January 1982.—*French Administration.*

Advanced motorway surveillance and control system in Netherlands

☐ An advanced motorway surveillance and control system has been installed on Motorway 13 between Rotterdam and The Hague. The system, developed by the Traffic Research Department of the Dutch Ministry of Roads and Waterways *(Rijkswaterstaat)*, was designed and implemented in co-operation with *Philips Nederland BV*'s Project Bureau and *Philips' Telecommunicatie Industrie BV*'s Traffic Group. Philips data systems computer equipment is used throughout the system.

The Motorway 13 system has been designated a demonstration project by the international co-operation group Euro-Cost 30, in which representatives of European governments study electronic aids to improve traffic conditions. The new system provides motorists with advice on suitable speeds per lane according to the traffic situation, the advice being given via "matrix-type" fibre optic indicators which are positioned over each lane.

In the case of an accident, the indicators can advise motorists to slow down, thus reducing the chance of a traffic jam and multiple pile-ups.

The motorway surveillance and control system continuously measures traffic density, gathering the data via sensors placed at 500 m intervals in the motorway's surface. These data are pre-processed by a microprocessor-equipped detection station at the roadside. The information from up to three of these detection stations is processed by a minicomputer in a so-called outstation, resulting in a brief description of the traffic situation in a lane section. This information is collected by a central computer system and processed into a complete analysis of the motorway situation every four seconds. The system uses this information to decide whether to take action, such as limiting speed or issuing warnings. These measures can be taken automatically by the system or by the system's operator based in the central control room near Delft, which is manned round the clock.

In the case of cable failure or other system management problems, the outstations will be able to switch the signs according to their own local traffic surveillance programs. A second system is expected to come into operation shortly at Ouderijn, near Utrecht, the Netherlands' main motorway junction. —*Philips.*

Broadcasting agreement for the Los Angeles 1984 Summer Olympic Games

☐ Following negotiations in Los Angeles, an agreement in principle has been reached between the European Broadcasting Union (EBU) negotiators, the Los Angeles Olympic Committee (LAOOC) and the International Olymic Committee (IOC). Under this agreement, the EBU acquires for its active members the right to broadcast the Los Angeles 1984 Summer Olympic Games in 31 European and Mediterranean countries.

The contract for a global sum of 19 800 000 USD covers the cost of rights and the provision of certain services and facilities.

The EBU Administrative Council, meeting on 25 November 1981, approved the terms of the agreement, which has also been accepted by the IOC and the LAOOC.—*EBU.*

News by satellite

☐ The first United Kingdom customer trials using satellite transmission and small dish earth stations at or near a customer's premises started in November 1981. A 3 m dish antenna and its associated electronic equipment were jnstalled on the roof of the *Financial Times* building in the City of London.

The antenna will beam digitized printing information from the Financial Times roof to an experimental European satellite, the Orbital Test Satellite *(OTS)*. The satellite will beam it down again to the Financial Times printers in Frankfurt.

When in full commercial use, the service, which British Telecom calls Satstream, will enable newspapers to publish simultaneously in cities all over western Europe.

Simultaneous printing of newspapers in different places is not new. The Financial Times prints in London and Frankfurt, the *Guardian* in London and Manchester, and the *International Herald Tribune* in Paris, London, Zurich and Hongkong. Hitherto these newspapers have been sending their printing data at a rather slow rate over landlines, so that a whole page takes some three hours to transmit.

Satstream will have several advantages over the current system. It will transmit printing instructions nearly 30 times faster than is possible over the present commercial network, and with a very low error rate. The satellites to be used in commercial operation will allow newspaper pages to be beamed down to a number of cities many hundreds of kilometres apart without taking up additional capacity in the satellites.—*British Telecom.*

In brief. . .

☐ Austria Microsystems International Ges.m.b.H (AMI), the new 50-million US dollar **joint venture** of *VOEST-ALPINE AG* in Austria and American Microsystems, Inc., in the United States, has named its Board of Directors and selected a site near Graz for its semiconductor electronics plant.

The plant will initially employ about 400 people, rising to 1200 when fully staffed. —*AMI.*

☐ A range of enhancements to digital PABXs, which will enable existing and future users of such systems to **integrate data, text and image communication needs within** their **existing voice network**, has been developed by Plessey Office Systems Limited. Products will be introduced in 1982.—*Plessey.*

☐ GTE Telenet and the Puerto Rico Telephone Company have jointly implemented **packet switching service between Puerto Rico and the continental United States,** using a Telenet-supplied packet switching gateway in San Juan. The gateway provides packet switching services within Puerto Rico and neighbouring islands as well as between Puerto Rico and the continental United States.—*GTE Telenet.*

☐ A contract to update communication equipment at a **satellite earth station** in Punta Arenas, Chile, has been awarded to GTE by *Empresa Nacional de Telecomunicaciones, SA* (ENTEL-CHILE), the company responsible for Chile's long-distance and international communications. The additional equipment will allow the station to operate with the recently launched *Intelsat-V* series of satellites.—*GTE.*

☐ In the sphere of data networks, which constitutes one of the main sectors of telecommunications development, *Thomson-CSF* and *Technique industrielle de Toulouse* (TIT) have decided to join forces and set up a **"groupement d'intérêt économique".**

The companies will have an equal share in the enterprise which is to be called *THOM-TIT* and which will pool the two companies' staff and industrial know-how in this sphere.—*Thomson-CSF.*

Personnel changes . . .

. . . in Liberia

□ Mr. Abdulai S. Vandi has been appointed Minister of Posts and Telecommunications, replacing Mr. George E. Saigbe Boley.

Technical News

"Seadog"

□ *Seadog*, a telecommanded submersible, is the latest addition to British Telecom's "navy" which maintains the network of undersea cables linking Britain with its islands, the rest of Europe and distant continents.

It has been designed for burying, inspecting and repairing underwater cable at a depth of up to 300 m. Operations are controlled from one of British Telecom's three cable ships to which *Seadog* is linked by umbilical cord.

Depending on seabed conditions, *Seadog* can cut trenches up to 1 metre deep at a rate of 2 nautical miles a day. A large capacity slurry pump, for lifting seabed material out of the trench, plus a matrix of cutting and fluidizing jets, combine to give much greater protection to cables during burial operations than present techniques.

820013

Seadog is extremely manœuvrable. It "flies" over the seabed to detect buried cable either visually or magnetically. It takes on water to ballast itself to its proper working weight and then drives along the bottom of the sea on tracks. Equipment which includes grippers and cutters is used to recover and repair cables.

Sea trials of *Seadog* (6.5 m long, 4 m wide and 3.5 m high) will be held early in 1982. The photograph shows a model of *Seadog*. In the background is British Telecom's Captain Lang and his cable ship, the *Alert*.—British Telecom.

A colour television powered by solar energy

□ *Salora* has recently developed a colour television operating on solar energy. Because of its extremely low energy consumption (less than 40 W), the viewers will be able to watch their colour receiver without the need for conventional accessories such as cables, contracts, etc. A solar sensor will supply all the energy needed by the television.

Salora has begun negotiations with an American company to market these *IPSALO* televisions in the Middle East.— *Finnfacts*.

SATELLITE LAUNCHINGS NOTIFIED DURING PERIOD 18 OCTOBER TO 20 NOVEMBER 1981

Code name Spacecraft description	International number	Country Organization Site of launching	Date	Perigee* Apogee	Period* Inclination	Frequencies Transmitter power	Observations
Venera-13 2 solar panels	1981-106-A	USSR (Baikonur)	30 Oct.	Earth-Venus trajectory			Automatic interplanetary station
No name	1981-107-A	United States	31 Oct.				
Cosmos-1317	1981-108-A	USSR	31 Oct.	636 km 40 165 km	726 min 62.9°		Early warning satellite
Cosmos-1318	1981-109-A	USSR	3 Nov.	183 km 379 km	89.8 min 67.2°		Reconnaissance satellite
Venera-14 2 solar panels	1981-110-A	USSR (Baikonur)	4 Nov.	Earth-Venus trajectory			Automatic interplanetary station
STS-2 Space Shuttle *Columbia*	1981-111-A	United States NASA (Eastern Test Range)	12 Nov.	219 km 229 km	89.0 min 38.0°		Re-usable spacecraft. Crew: Joe Engle and R. Truly. Objectives: to demonstrate re-usability of the launch vehicle, capability of supporting scientific and applications research with the Office of Space and Terrestrial Applications payload (OSTA-1) and to conduct remote manipulator system tests. Landed on 14 November 1981. Mission was curtailed owing to failure of a fuel cell generator

Code name Spacecraft description	International number	Country Organization Site of launching	Date	Perigee* Apogee	Period* Inclination	Frequencies Transmitter power	Observations
Cosmos-1319	1981-112-A	USSR (Plesetsk)	13 Nov.	216 km 400 km	90.4 min 70.4°		Reconnaissance satellite
51st Molnya-1 hermetically-sealed cylinder with conical ends; mass: 1000 kg; 6 solar panels	1981-113-A	USSR (Plesetsk)	17 Nov.	472 km 39 117 km	702 min 62.8°	800 MHz band 40 W (emission) 1000 MHz band (reception) 3400-4100 MHz (retrans-mission of television)	Television and multichannel radio-communications
RCA-Satcom-3R 3-axis stabilized satellite; 1.62 × 1.27 × 1.29 m; mass: 895 kg; 2 solar panels	1981-114-A	United States RCA Corporation (Eastern Test Range)	20 Nov.	in geostationary orbit at 132° W		2241.5; 2244.5 MHz 5 W 2237.5 MHz 2.5 W	United States national communications satellite. Twenty-four transponders, each of which can handle 1200 voice-grade channels, one colour television transmission or more than 60 Mbit/s data

* Initial orbital data.

Sources: COSPAR, NASA, Specialized Press.

New Products

Family of PBXs

□ A new series of electronic private branch telephone exchanges (PBXs) for small and medium-sized businesses is being launched internationally by *Philips*.

The new TBX *T*ime-division *B*ranch e*X*change) systems offer the following main features:

— very low space and power requirements, a quarter of those required previously;

— modular design of both hardware and software, allowing rapid expansion or reconfiguration of systems as users' needs change;

— high transmission quality, covering not only the speech band but frequencies up to 5600 HZ, allowing transmission of data, text and facsimile at speeds up to 9600 bit/s;

— digital control by stored programs. These provide many convenience features as standard and allow others, specific to the individual installation, to be entered and altered via the operator's console;

— an unusually high traffic capacity (0.28 erlang per extension, 60% higher than most systems);

— freedom to choose a mixture of rotary-dial (pulse train) and push-button (multi-frequency tone) handsets for internal extensions, regardless of which system the public network uses;

— great reliability, resulting from use of ceramic integrated circuits and large-scale integration, followed by factory assembly and testing of exchanges before shipping;

— easy maintenance. The system needs no preventive maintenance because it constantly checks itself. If any faults occur, they can rapidly be traced to a particular circuit on a particular card with the aid of a maintenance processor unit—either through the operator's console or remotely from a telephone service centre via the public telephone system. This remote diagnostic facility will be of great value both in congested city centres, where car parking is difficult, and for remote installations far from telephone service centres. Once a system fault is located, the faulty circuit-card can be replaced within seconds by unskilled labour.

The first of the TBX models available offers full flexibility by the addition of appropriate cards (with four exchange-lines or eight extension-lines per card) up to a maximum of 96 port positions. Later versions will allow the system to expand to almost 900 port positions, utilizing the same type of exchange- and extension-line cards.

Time-division multiplexing

The small size of the new TBX exchanges results largely from the use of a time-division multiplexing switching system, which permits a single communications highway to be used. The system uses modulation techniques with 48 multiplex channels and a sampling frequency of 24 kHz.

Two crucial components were developed specially for the exchanges. These are a

multiplexer/demultiplexer chip, and a hybrid for interfacing 2-wire telephone connections with the 4-wire switching network. The resulting insertion loss is less than 1 dB and crosstalk attenuation better than 70 dB over the whole 300-3400 Hz speech band.

Exchanges are controlled by stored programs using C-MOS microprocessor logic. PROM memories hold standard instructions and RAMs hold installation-specific information. Data once entered in RAM is protected from unauthorized changes.

Wall mounting

A complete exchange with, typically, 8 external lines and 80 internal extensions fits into a self-supporting wall cabinet measuring 42 ×86 × 51 cm and weighing 55 kg. Numbers of internal or external lines can be changed rapidly by plugging in additional or different circuit-cards and PROMs.

Power consumption of just 130 W per shelf may be taken from the mains through an ordinary domestic socket. A standby battery protects the system from mains failure.

The new TBX systems will be manufactured in the Netherlands, Spain and Brazil.

Philips' Telecommunicatie Industrie BV, PO Box 32, 1200 JD Hilversum (Netherlands). Telex: 43712

Subscriber telex and telephone combiner

☐ This new system allows a standard 2-wire telephone cable pair to be shared by telex and telephone services. The *SDX 1/50* system allows telecommunication authorities to provide a new telex service quickly to telephone subscribers in areas where cable capacity is limited and where delays in providing costly new cables are to be expected. The system comprises two boxes, one of which is installed in the subscriber's premises and the other in the local exchange.

As the system is simple to install, new subscriber service can be provided and revenue earned much earlier than is possible using conventional connection techniques. When telex cables do eventually become available the SDX 1/50 can then be simply moved on to a new location.

The system operates by slightly reducing the bandwidth of the telephone circuit (to 2.7 kHz), which is practically undetectable, and uses the remainder of the spectrum (to 3.4 kHz) to provide a normal duplex 50 baud telegraphy circuit.

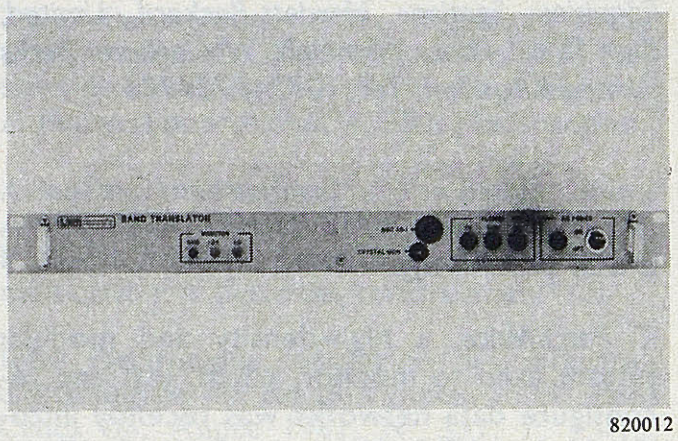
The SDX 1/50 works on any 2-wire circuit which is presently usable for telephony. The system is particularly suitable for use on crowded cables in urban areas and also for providing telex services to remote farms or industries which may be a long distance from the nearest exchange.

Telectron Limited, Astral House, Adelaide Road, Dublin 2 (Ireland)

Band translator for reception of Ku-band satellite signals using C-band equipment

☐ LNR's model *DC12/4* is a high performance Ku to C-band frequency translator. With the DC12/4 on line, C-band receiving equipment is immediately converted for K-band use; the DC12/4 provides block down conversion of the entire 11.7-12.2 GHz frequency assignment to 3.7-4.2 GHz.

Alternatively, the DC12/4 can be used to downconvert a Ku-band video signal into an unusued channel in a 24-channel C-band television receiver at a cable television head end.



820012

The DC12/4 interfaces directly with a 12 GHz LNA and 4 GHz receivers or converters, and is suitable for video message or data carriers. The unit is self-contained including power supply. It is designed for unattended operation, and has a remotable summary alarm, as well as front panel monitors for key operating parameters. The DC12/4 is compact, measuring only 45 mm in height, and is designed for rack mounting. Available options include 1:1 protection switching.

LNR Communications Inc., 180 Marcus Boulevard, Hauppauge, NY 11787 (United States). Tel.: (516) 273-7111. TWX: 510-227-9871

HF antenna

☐ A new addition has been made recently to the Marconi range of wideband HF antennae.

The *R7080 Conipole* is a vertically polarized system specifically designed for medium- and long-range applications. It incorporates a number of features both to increase performance and to ease handling and maintenance.

The Conipole covers the range 1.6 to 30 MHz, both in the transmitting and in the receiving mode, and will handle up to 30 kW of transmitter power. Based on a sleeve dipole, in which the sleeve takes the form of a skirt that spreads from the supporting mast, advantages include presenting an ideal launching mode for low-angle waves and the minimization of reflexions. The upper part of the antenna, in which the coaxial input feeder is situated, comprises an umbrella-top of sloping wires supported and insulated from an earthed mast. This reduces antenna height by some 25% and eliminates the need for a base insulator.

Marconi Communication Systems Limited, Chelmsford CM1 1PL (United Kingdom). Tel.: (0245) 353221. Telex: 99201

Low capacity point-to-point radio relay

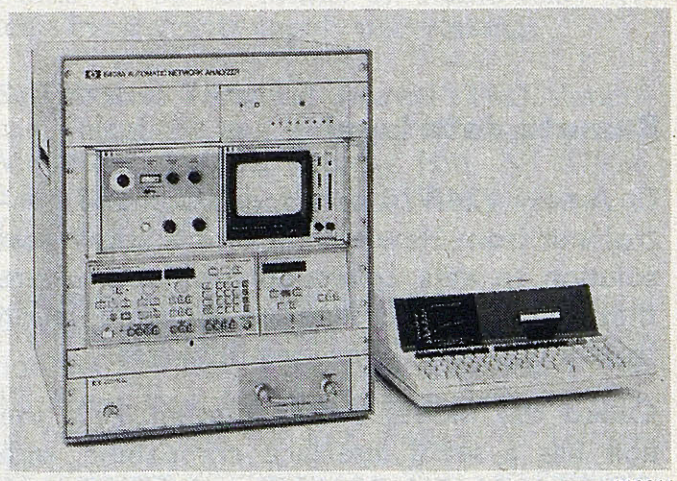
☐ A low-capacity point-to-point radio relay, the *PRS 770*, has been introduced by Plessey Radio Systems.

The rugged, reliable and low-cost equipment provides one or two voice channels in the 1.5 GHz frequency range and is suitable for voice or data systems. It may be mounted internally or externally. Servicing is simple and power consumption low.

Plessey, c/o Parker PR Associates Limited, 22 Red Lion Street, London WC1R 4PX (United Kingdom). Tel.: (01) 405 3353

Automatic microwave network analyser

☐ Hewlett-Packard's model *8408A* automatic network analyser is a 500 MHz to 18 GHz system for measuring the magnitude and phase of reflection and transmission coefficients. Phase measurements provide the means to make error-corrected measurements which in turn permit the HP 8408A to perform accurate, repeatable tests.



820011

Major elements of the HP 8408A system are the *HP 8350A* microprocessor-based sweep oscillator with *HP 83592A* 10 MHz-20 GHz RF plug-in for the test signal source; the *HP 8410* microwave network analyser system with a specially configured 500 MHZ-18 GHz reflection transmission test set for signal separation, detection and analysis; and the economical *HP-85F* desktop computer serving as the system controller, data collector/processor and displayer of results. The system is packaged in a convenient bench-top rack assembly. Included with the system are precision calibration standards and a comprehensive software applications package.

Typical measurement ranges for the HP 8408A are 60 dB for transmission and 50 dB for reflection. These ranges are free from the effects of source harmonics and spurious signals because the 8408A's analyser is a tuned receiver. (Scalar systems are not immune to source harmonics and spurious signals because they use broadband detection.) The tuned receiver also has high sensitivity (typically –70 dBm) which means small signal devices can be safely tested. A major contribution of the 8408A is its ability to measure its systematic errors, store them, and then vectorially subtract them from routine measurement data. The resultant accuracy enhancement provides high effective directivity even if cables or adapters are in the test setup. Accuracy enhancement also improves transmission measurement accuracy by reducing source match effects (typically to 1.05 SWR) and virtually eliminating frequency response errors. These accuracy enhancement techniques are not possible with scalar (non-phase) measuring systems.

The system software permits the user to make measurements immediately. Simple prompts guide the operator through the complete initial setup, calibration, measurements, and output sequences.

Results can be displayed on the computer's CRT and printed in tabular form, plotted versus frequency or in polar format. In addition, the receiver/analyser has a real-time CRT display of swept magnitude and phase which permits the operator to see the effects of adjustment on the device under test.

Enquiries Section, Hewlett-Packard Ltd., King Street Lane, Winnersh, Wokingham, Berks. (United Kingdom). Tel.: (0734) 784774

Remote data logging

☐ A new *V24/V10* data acquisition and control unit from Hewlett-Packard is a low-cost solution to data collection problems where there is a need to separate instrumentation from a computer over long distances.

Called the model *3497A* Option 232, the unit has a serial interface compatible with CCITT V.24 (EIA RS232C) and CCITT V.10 (EIA RS423) specifications. Point-to-point connection up to 1200 m between a computer and the 3497A data acquisition/control unit is possible. For extremely long-distance communications, the HP 3497A Option 232 is compatible with full duplex RS232 or RS423 asynchronous modems. Eight baud rates available (110, 300, 600, 1200, 2400, 4800, 9600 and 19 200) match digital transmission rates to modems and telephone lines. Even or odd parity can be selected, including 7- or 8-bit character length.

Similar to the standard HP 3497A, Option 232 also includes a clock/timer. Analogue channels and/or digital slots and DC voltage are displayed. Available plug-in card assemblies include; built-in 3, 4 or $5^1/_2$ digit DVM; 20-channel, low thermal, reed-relay card with thermocouple compensation; 16-channel actuator output card; dual output voltage D to A card; dual output current D to A card; 100 kHz reciprocal counter card; strain gauge completion card; high voltage actuator card; and *3498A* slave extender capable of accepting 10 plug-in card assemblies per extender.

Option 232 accepts up to 5 plug-in card assemblies. With the appropriate number of 3498A slave extenders a maximum of 1000 analogue channels and 1350 digital channels can be accommodated.

Enquiries Section, Hewlett-Packard Limited, King Street Lane, Winnersh, Wokingham, Berks (United Kingdom). Tel.: (0734) 784774

Data patching

☐ *PatchMate*, a high-density and modular system used to monitor, patch, test and reconfigure data networks was recently introduced by ADC Magnetic Controls Company.

The system enhances data network management by monitoring data circuits without interruption, identifying down circuitry with both visual and audible alarms, and providing line access on RS-232C/V.24 circuits toward both the terminal and communications end of that data equipment.

PatchMate occupies only 134 mm in a standard 483 mm rack with each rack holding up to 17 modules. The total system is modular in design, thus offering the user one-for-one substitution of different function modules in any rack, and the built-in feature of add-on growth for expanding data networks.

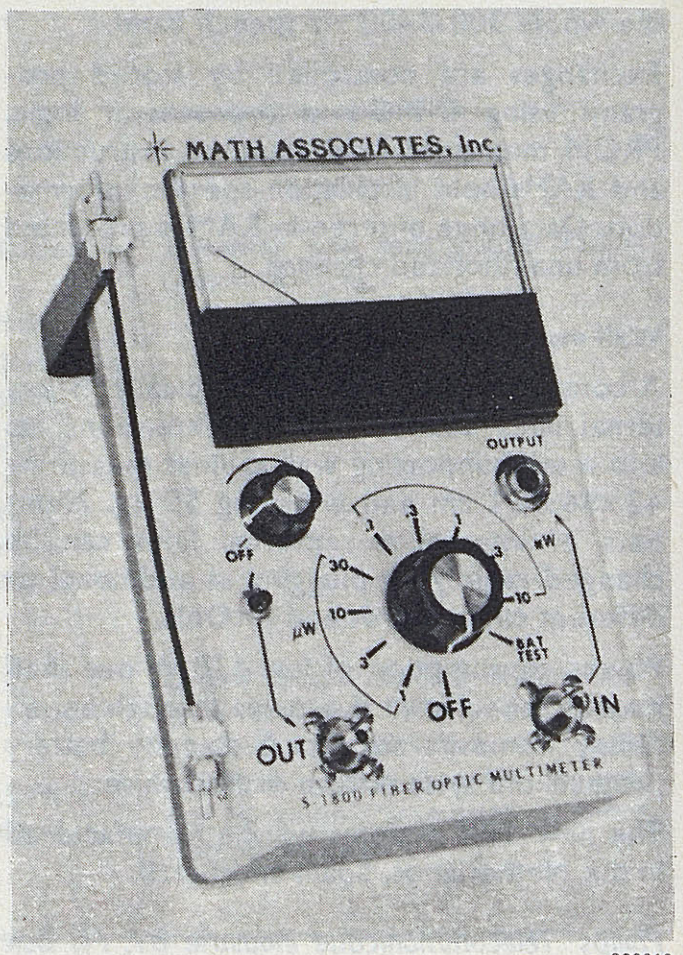
ADC, Communications Department, 4900 West 78th Street, Minneapolis, MN 55435 (United States). Tel.: (612) 835-6800. Telex: 29-0321

Fibre optic multimeter

☐ What is believed to be the first true fibre optic multimeter for the testing and troubleshooting of all fibre optic transmission systems (analogue or digital) as well as fibre optic cable is announced by Math Associates.

The *S-1800* will allow fibre optic transmitters, receivers, couplers, splitters, connectors, splices and complete cables from 50 μm core diameter to 1000 μm to be fully tested with one portable, self-contained unit. Parameters such as power output, sensitivity, insertion loss, modulation and attenuation are quickly determined with the results displayed on a large, analogue-type meter, calibrated in microwatts and decibels.

Contained within the S-1800 is a calibrated power meter, variable infra-red LED source, and facilities for checking modulation of both transmitters and receivers.



820010

S-1800 fibre optic multimeter

The S-1800 fibre optic multimeter is fully self-contained and may be operated from an internal 9 V battery or an optional AC adapter. It is suitable for field or laboratory use and is supplied with all accessories in an SMA or AMP optimate compatible version.

Math Associates Inc., 6 Manhasset Avenue, Port Washington, NY 11050 (United States). Tel.: (516) 944-7050

PAL/SECAM/NTSC colour television decoder ICs

☐ Three new integrated circuits are announced by *Philips*—the *TDA3561* and *TDA3562* single-chip colour decoders, and the *TDA3590* processor. These ICs, together with the earlier-introduced *TDA3560*, form the Philips range of third-generation colour decoders.

The 28-pin TDA3560 is a complete *PAL* colour decoder. It accepts data insertion for teletext, and includes a peak-white limiter.

The 28-pin TDA3561 is similar to and pin-compatible with the TDA3560, but has extra features such as a line period delay from the peak-white limiter, and a black-level/output-signal ratio of less than 2% between the different channels.

The 28-pin TDA3562 is also similar to the TDA3560, but is not pin-compatible. It has contrast control of inserted RGB signals, black-level stabilization of the colour guns,

dynamic adjustment of black-level throughout the picture tube's life, and the ability to decode *NTSC* with hue control.

The TDA3590 processor circuit is for connection in front of a colour decoder IC. It leaves incoming PAL signals unchanged, but automatically converts *SECAM* signals to a sequential phase-modulated signal for decoding by a PAL decoder. When the TDA3590 is connected in front of the TDA3560 or TDA3561, the combination forms a PAL/SECAM colour decoder; when it is connected in front of the TDA3562, the combination forms a PAL/SECAM/NTSC colour decoder. The TDA3590 has undergone extensive field testing, and gives excellent performance even with non-standard or reflected incoming signals.

NV Philips' Gloeilampenfabrieken, Elcoma Division, PO Box 523, 5600 AM Eindhoven (Netherlands). Telex: 51573

High-power hybrid-ferrite transmitter combiners

□ Two new hybrid-ferrite transmitter combiner series have been added to Phelps Dodge Communications Company's product line. One series couples VHF transmitters to a common antenna while the other is designed for UHF applications.

The 136-174 MHz *THC150* and *THD150* series provide antenna coupling to VHF transmitters and have a maximum power input of 350 W per channel. The 406-512 MHz *THC460* and *THD460* series couple UHF transmitters and operate at up to 300 W per channel. Channel isolation for the THC150 and THC460 combiners is at least 70 dB, and at least 100 dB for the THD150 and THD460 models. All models operate with frequency separations down to 25 kHz.

The hybrid-ferrite transmitter combiners operate from −30 to +60° C, and have a maximum VSWR of 1.25:1. Both series are available in 2 or 4 channel configurations.

Phelps Dodge Communications Company, Route 79, Marlboro, NJ 07746 (United States). Tel.: (201) 462-1880.

CORRIGENDUM

A misprint occured in our description of a **lightning pulse counter**, manufactured by *Itronic Fuchs GmbH*, published on page 696 of our November 1981 issue. The text should read: The device offers a means of recording pulses of a specified amplitude over the range of 100 to 2000 V.

Review of Reviews

A list of articles in other technical publications which may be of interest to readers of the Journal. The articles are listed under the language of the publication.

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Title: YEARBOOK OF COMMON CARRIER TELECOMMUNICATION STATISTICS (Chronological Series 1970-1979)

Summary: This publication is an official service document published by the General Secretariat of the International Telecommunication Union in pursuance of Resolutions Nos. 4 and 5 of the World Administrative Telegraph and Telephone Conference (Geneva, 1973) and Recommendation C.1 of the International Telegraph and Telephone Consultative Committee (CCITT).

The Yearbook contains a collection of data on the various branches of common carrier telecommunications, namely, the telephone service (number of stations and traffic), the telegraph service (number of connections and traffic) and the data transmission service (number of modems). It also gives information on revenue and investments.

All of the information is published in chronological series, recapitulating the figures for the years 1970 to 1979.

Format	Binding	Edition	Date	Languages	Number of pages
21 × 29.7 cm	paperback	8th	1980	Trilingual edition **F, E, S.**	358

Price: 37 Swiss francs

ISBN 92-71-01064-7

Title: GENERAL PLAN FOR THE DEVELOPMENT OF THE INTERREGIONAL TELECOMMUNICATION NETWORK, 1980-1983-1987 (PARIS, 1980)

Parts 1 and 2

Plan Committees

A World Plan Committee and several Regional Plan Committees were set up to " develop a General Plan for international telecommunication network to facilitate co-ordinated development of international telecommunication services" (International Telecommunication Convention, Malaga-Torremolinos, 1973).

Summary: This book is published in accordance with the recommendations made by the World Plan Committee for the development of telecommunication networks at its meeting in Paris from 9 to 18 April 1980 and replaces the one prepared by the Committee at its meeting in Geneva in 1975.

This General Plan, consisting of two parts, is designed to help administrations and recognized private operating agencies (RPOAs) when, exercising their full sovereignty, they conclude mutual agreements for the organization or improvement of international services between their respective countries.

Part 1

It contains:

— statutory texts relative to the work of the Plan Committee, and a list of the Plan Committees;

— information on arteries, as contained in five lists mentioned below, and a map:

- — List No. 1: Long-distance *interregional* metallic lines;
- — List No. 2: *Interregional* radio-relay systems;
- — List No. 3: *Interregional* HF radio circuits;
- — List No. 4: *Interregional* telephone-type submarine cables;
- — List No. 5: Communication satellite sytems and earth stations for satellite communications;
- — world-wide telephone numbering plan and world-wide telex and gentex numbering plan;
- — leased services.

→

Format	Binding	Edition	Date	Languages	Number of pages
2 volumes 21 × 29.7 cm	paperback	1st	1980	Trilingual edition **F, E, S.**	**Vol. I:** 135 **Vol. II:** 303

Price: 148 Swiss francs (for the 2 volumes which are not sold separately)

ISBN 92-71-01037-X

Title: ALPHABETICAL LIST OF CALL SIGNS OF STATIONS USED BY THE MARITIME MOBILE SERVICE, SHIP STATION SELECTIVE CALL NUMBERS OR SIGNALS AND COAST STATION IDENTIFICATION NUMBERS OR SIGNALS

(List VII A)

Summary: Service document drawn up by the General Secretariat and published by authority of the Secretary-General of the International Telecommunication Union in accordance with the provisions of Nos. 789, 809 Mar and 815 Mar2 of the Radio Regulations, Geneva (1976 edition, revised in 1981).

The List is published every two years in a multilingual edition (French, English, Spanish, Russian and Chinese). It is kept up to date by quarterly supplements.

This edition of the Alphabetical list of call signs contains six parts as follows:

Preface

Part I — Tables of general interest.

Part II — Alphanumerical list of signals characterizing the emissions of radiobeacons used in the maritime mobile service and whose particulars appear in the List of radiodertermination and special service stations (List VI—Vol. I).

Part III — Alphanumerical list of call signs of coast, ship, radiodetermination and special service stations the particulars of which are contained in the List of coast stations (List IV), the List of ship stations (List V), or List VI. Collective call signs notified by the administrations are also included.

Part IV — Numerical list of selective call numbers of ship stations the particulars of which are contained in List V. Selective call numbers for selective calling of predetermined groups of ship stations notified by the administrations are also included.

Part V — Numerical list of identification numbers of coast stations the particulars of which are contained in List IV.

Part VI — Notes.

Format	Binding	Edition	Date	Languages	Number of pages
21 × 29.7 cm	paperback	9th	1979	multilingual edition **F, E, S, R, C.**	238

Price: 28 Swiss francs

Part 2

It contains the information supplied by administrations and recognized private operating agencies in response to the Questionnaire on the World Plan 1980 contained in CCITT circular No. 143 dated 18 June 1979.

As 1979 was taken as the base year, the data refer to:

— interregional traffic (showing traffic volume in 1979 and forecasts for the years 1980 to 1987),

— traffic routings,

— existing circuits (1979),

— international switching centres,

— details of plan for international user services.

Each administration or recognized private operating agency has supplied data on every country in other Regions with which outgoing traffic levels in the base year (1979) exceeded:

a) *for telephone traffic:* 10 000 paid minutes annually;

b) *for telex traffic:* 10 000 paid minutes annually;

c) *for telegraph traffic:* 100 000 paid words annually.

To facilitate consultation, data in this part have been published in six tables:

Table I — Telephony. Traffic — Routing — Circuits

— Outgoing traffic in paid minutes (thousands) per year and growth factor

— Busy hour traffic in erlangs and growth factor

— Circuits and transit routing

Table II — Telex. Traffic — Routing — Circuits

— Outgoing traffic in paid minutes (thousands) per year and growth factor

— Busy hour traffic in erlangs and growth factor

— Circuits and transit routing

Table III — Telegraphy. Traffic — Routing — Circuits

— Outgoing traffic in paid words (thousands) per year

— Circuits and transit routing

— Telegraph-type circuits

— Telephone-type circuits

Table IV — Wideband circuits (sound programme, television or other services)

Table V — International switching centres

Table VI — Details of plans for international user services

All the tables in a given category, I to VI, constitute a separate section in which all the originating countries are listed in the alphabetical order of their symbols. In each of the tables, the countries of destination are listed by region according to the alphabetical order of their designated symbols. The list of symbols and countries is given at the beginning of Part 1 of the Book.

The documentation supplied refers to interregional traffic only. Information on regional traffic is published in the Books of the Regional Plan Committees.

In order to be able to have more up-to-date information, Part 2 will be published every two years (next publication in 1982, on the basis of data for 1981).

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Books

by A. El-Zanati

INTERNATIONAL CONFERENCE ON CONTROL AND ITS APPLICATIONS[1]

(University of Warwick, 23-25 March 1981)

(IEE Conference Publication No. *194*)

Organized by the IEE Computing and Control Division, in association with the Institute of Electrical and Electronics Engineers (Control Systems Society, etc.), the Institute of Mathematics and its Applications, the Institute of Measurement and Control, the Institute of Physics, the Institution of Chemical Engineers, the Institution of Electronic and Radio Engineers, and the Institution of Mechanical Engineers, the International Conference on control and its applications was held at the University of Warwick, United Kingdom, from 23 to 25 March 1981. Seventy-three papers were presented to the conference and are reproduced in this volume which should prove useful to all specialists interested in this subject.

[1] *One paperback volume; pp. xii + 387; tables, diagrams, illustrations. 21 × 29 cm. Published by the* Institution of Electrical Engineers, *Savoy Place, London WC2, 1981. Price: 27.60 pounds sterling.*

TUTORIAL: DISTRIBUTED PROCESSING[2]

(Third edition)

by Burt H. Liebowitz and John H. Carson.

The purpose of this tutorial is to provide an introduction to distributed processing concepts which can be used to determine the relevance of a distributed processing approach to the reader's computing needs. This tutorial emphasizes the technological issues reflecting the greater availability of literature dealing with technical issues. It also reflects the observation that management issues often are resolved more for political, personnel, or historical reasons than by the application of well-established analytical principles.

The broad scope of distributed processing is reflected in the organization of this tutorial. There are nine chapters, including the introduction. Chapters 2 to 4 discuss basic building blocks of distributed systems, computers, communications, and terminals. Chapter 5 describes resource-sharing networks, while chapter 6 discusses multiple-processor systems (MPS). Chapter 7 discusses multiprocessors which are tightly coupled multiple-processor systems, and chapter 8 describes the problems and potential benefits associated with distributed databases. Finally, chapter 9 describes local area networks. These are collections of computers and terminals that are located in the same building or a campus of buildings.

Each chapter contains an introductory discussion of the subject material and a set of reprints of current articles containing more detailed information on the subject matter.

[2] *One paperback volume: pp. vi + 640; tables, diagrams, illustrations, 21 × 28 cm. Published by* IEEE Computer Society, *10662 Los Vaqueros Circle, Los Alamitos, CA 90720, 1981.*

LOGISCHER ENTWURF DIGITALER SYSTEME[3]

Zweite, überarbeitete Auflage

(Logic design of digital systems, 2nd revised edition), by Wolfgang Giloi and Hans Liebig.

Contents of this advanced students' textbook include: propositional calculus and Boolean algebra; Boolean algorithms; combinational circuits; combinational chains; asynchronous sequential circuits; synchronous sequential circuits and microprocessors; etc.

[3] *One bound volume; pp. xii + 328; diagrams. 17 × 24 cm. Published by* Springer-Verlag, *Heidelberger Platz 3, D-1000 Berlin 33, 1980. Price: 48 Deutsche marks.*

A TUTORIAL REVIEW OF THE NEW EMI MODELS AND THEIR EFFECTS ON RECEIVER PERFORMANCE[4]

by David Middleton *(NTIA Report CR-80-7).*

New models of electromagnetic interference (EMI) have been developed by the author during the period 1974-1979, which for the first time have provided a canonical, analytically tractable, and experimentally well-established quantitative description of nearly all EMI environments. These models are:

1) physically derived;

2) canonical in the sense that they are invariant of the nature and waveform of the source and details of preparation, as far as their formal analytical structure is concerned;

3) highly non-gaussian;

4) analytically and computationally manageable.

The principal aim of this report is to present a tutorial review of the main features of the work to date on these models and their current and potential applications. Analytical details are reserved to an appendix, and the full technical analysis and results are specifically cited in an extensive list of selected references.

[4] *One paperback volume; pp. vi + 66; tables, diagrams. 21 × 28 cm. Published by* US Department of Commerce, NTIS, *5285 Port Royal Road, Springfield, VA 22161, 1980. Price: 16 US dollars.*

DIGITAL COMMUNICATIONS: MICROWAVE APPLICATIONS[5]

by Kamilo Feher.

Digital microwave communications systems have been developed to provide high quality, reliable communications for digitized voice and video signals. Digital systems are particularly useful for interlinking computers and other digital sources over long- and short-haul transmission media. In this book, transmission concepts and techniques of digital systems are presented. Practical state-of-the-art implementation of digital communication systems by line-of-sight microwaves are also described.

Contents include: transmission system environment; digital modulation methods; system gain; the concept and its applications; digital and hybrid system potpourri; digital microwave systems design; diversity and protection switching techniques; etc.

[5] *One bound volume; pp. xviii + 269; tables, diagrams, illustrations. 18 × 24 cm. Published by* Prentice-Hall, Inc., *Englewood Cliffs, NJ 07632, 1981.*

ADJUSTABLE SPEED AC DRIVE SYSTEMS[6]

edited by Bimal K. Bose *(IEEE Press Selected Reprint Series).*

Solid-state speed control of AC motors is becoming increasingly popular for various industrial applications. With the present trend of technology, widespread application of adjustable speed AC drives seems inevitable in the near future.

This book opens with a section, specially written by the editor, reviewing the state-of-the-art of AC drive technology and giving projections for the future. Fifty carefully selected papers, reprinted from the vast literature on the subject, follow. These are divided by subject into the following parts and sections: induction motor drives: (phase controlled converter drives; voltage fed inverter drives; current fed inverter drives; slip power controlled drives); synchronous motor drives: (current fed inverter drives; cycloconverter controlled drives). The book ends with a selected but extensive bibliography, which is also categorized by subject.

[6] *One bound volume; pp. x + 449; tables, diagrams, illustrations. 22 × 28 cm. Published by the* Institute of Electrical and Electronics Engineers, Inc., *345 East 47th Street, New York, NY 10017, 1981.*

COMPARISON OF AVAILABLE METHODS FOR PREDICTING MEDIUM FREQUENCY SKY-WAVE FIELD STRENGTHS[7]

by Margo PoKempner *(NTIA Report CR-80-42).*

The chronological development of the available methods for predicting medium frequency sky-wave field strengths is presented with a brief discussion of each method. Measured field strengths for 36 medium frequency sky-wave paths are compared with the predicted field strengths from several different prediction methods. Based on the rms errors between observations and predictions, the 1938 Cairo Curves provide the best estimates of the sky-wave field strengths for very long paths world wide. A new prediction method, developed for use in North and South America only, provides improved estimates of the sky-wave field strengths for paths <3500 km.

[7] *One paperback volume; pp. iv + 94; tables, diagrams. 21 × 28 cm. Published by* US Department of Commerce, NTIS, *5285 Port Royal Road, Springfield, VA 22161, 1980. Price: 19 US dollars.*

TELECOMMUNICATIONS—TRENDS AND DIRECTIONS[8]

(Hyannis, 27-29 May 1980)

edited by Electronic Industries Association.

This is a compilation of papers presented at the fifth annual Telecommunications —trends and directions seminar held from 27 to 29 May 1980 in Hyannis, Massachusetts, United States. It provides an up-to-date overview and detailed projections of the important segments of the telecommunications industry.

Subjects covered include: the convergence of telecommunications and data processing; modern data communications networks; the phenomenon of the home/small business computer; satellite communications and direct satellite television reception; the digital network; etc.

[8] *One paperback volume; pp. 111, tables, diagrams. 21 × 28 cm. Published by* Electronic Industries Association, *2001 Eye Street, NW, Washington, DC 20006, 1980. Price: 10 US dollars.*

OPTICAL FIBER TECHNOLOGY, II[9]

edited by Charles K. Kao *(IEEE Press Selected Reprint Series).*

The technology of optical fibres has reached that state of maturity where the production phase has begun and new applications are being announced with regularity. It is incumbent on workers in a variety of fields to keep up to date on developments in this important and growing technology.

This book provides the reader with a broad background on the latest progress with optical fibres. From several thousand available publications, the editor chose 37 of the best papers to be reprinted. These are arranged by subject into the following parts: introduction and survey; fibre waveguide theory; materials and fabrication; measurement; fibre cable; radiation effects; connector splices and couplers; fibre transducers; receivers; system design; and applications.

[9] *One bound volume; pp. viii + 343, tables, diagrams, illustrations. 22 × 28 cm. Published by the* Institute of Electrical and Electronics Engineers, Inc., *345 East 47th Street, New York, NY 10017, 1981.*

COMPARISONS OF ANALYTICAL AND NUMERICAL CALCULATIONS OF COMMUNICATIONS PROBABILITY[10]

by L. A. Berry *(NTIA Report CR-80-41).*

Middleton's analytical formula for the probability of communications in a land mobile environment and Berry's computer program for probabilistic calculations of interference are shown to produce identical answers for identical inputs. The assumptions, input, and output of the two models are compared. Middleton's assumption that interfering sources transmit randomly and independently is of particular interest for mobile radio services. The effects of the greater variety of input assumptions possible with the computer method are illustrated numerically.

To use Middleton's formula to compute the probability of interference for a detailed scenario, the parameters of class A noise must be determined from the scenario descriptors. Methods for finding these parameters are explored.

[10] *One paperback volume; pp. vi + 63; tables, diagrams. 21 × 28 cm. Published by* US Department of Commerce, NTIS, *5285 Port Royal Road, Springfield, VA 22161, 1980. Price: 16 US dollars.*

TUTORIAL ON STRUCTURED PROGRAMMING: INTEGRATED PRACTICES[11]

by Victor R. Basili and F. Terry Baker

This tutorial is a major rewrite of the earlier tutorial entitled "Structured programming" by the same authors. Its purpose is to provide an integrated set of techniques that can be used throughout the software development process. This integrated set of techniques makes up what has been commonly labelled structured programming methodology, which covers the design, development, and validation of software, as well as the organizational structure required to execute the methodology in a product environment.

Section I presents an overview. Section II deals with the basic definitions of the concepts with an emphasis on readability and correctness. Section III deals with the actual design and development process. Section IV discusses segmentation/modularization and techniques for creating a well-segmented program. Section V talks about the top-down procedure called "iterative enhancement." Section VI describes software development libraries as well as their application in a particular programming environment. Section VII deals with the concepts of structured walk-throughs and design inspections. Section VIII discusses the organization of people by presenting the chief programmer team concept and how it is applied to a particular product and environment.

[11] *One paperback volume; pp. vi + 290; tables, diagrams, illustrations. 21 × 28 cm. Published by* IEEE Computer Society, *10662 Los Vaqueros Circle, Los Alamitos, CA 90720, 1981.*

Requests for tenders

We should be obliged if any administrations wishing to make use of this column would send us their tenders if possible three months before the closing date for bids.

TUNISIA

To meet service requirements, the Tunisian Ministry of Transport and Communications proposes to acquire **systems for the capture, directly on magnetic tape, of information provided by telephone meters** located in automatic exchanges.

The tape will be processed by an invoicing computer.

Potential suppliers are requested to send their tenders, together with prospectuses, to the following address: "Ministère des Transports et des Communications, Direction des Services communs, Sous-direction de l'approvisionnement, 3 bis, rue d'Angleterre, Tunis (Tunisie)".

Tenders should indicate FOB and CIF prices, the delivery period and terms of payment.

Note from the CCIR

Basic Indices for Ionospheric Propagation

THE FOLLOWING TABLES, giving values of the basic indices for ionospheric propagation, have been prepared by the Specialized Secretariat of the International Radio Consultative Committee (CCIR) in accordance with Resolution 4-2 and Recommendation 371-3 of the XIVth CCIR Plenary Assembly (Kyoto, June 1978). In order to expedite the dissemination of the predictions the CCIR Secretariat prepares a monthly circular which is sent to administrations, about the 10th of each month, in conformity with the conditions given in circular letter No. A.C./131 of 14 February 1969. Copies of these predictions may be obtained, free of charge, from the Director of the CCIR, ITU, Place des Nations, CH-1211 Genève 20, Switzerland.

Parameters:

R_{12} (smoothed mean, over twelve months, of the number of sunspots observed)

Year \ Month	1	2	3	4	5	6	7	8	9	10	11	12
1980	165	163	162	159	157	155	153	151	150	150	148	143
1981	140	141	143	143	143	141						

I_{F2} (ionospheric index)*

Year \ Month	1	2	3	4	5	6	7	8	9	10	11	12
1980	145	143	158	154	176	168	155	145	151	183	164	164
1981	130	141	163	172	168	148	134	156	190	185	172	164

* *For further details, see the* Telecommunication Journal, *April 1964, page 119, and January 1966, pages 43-47.*

Φ (monthly mean value of solar noise flux at 2800 MHz at 17h00 UTC)**

Year \ Month	1	2	3	4	5	6	7	8	9	10	11	12
1980	206	200	168	208	224	193	185	166	184	204	218	225
1981	175	204	206	223	195	157	192	221	220	224	208	208

** *Data kindly supplied by the National Research Council, Ottawa.*

Φ_{F2} (ionospheric index)***

Year \ Month	1	2	3	4	5	6	7	8	9	10	11	12
1980	203	195	197	196	216	218	190	179	181	199	195	197
1981	186	198	201	195	209	177	166	185	209	193	203	195

*** *For further details, see the* Telecommunication Journal, *September 1967, pages 354-356, and December 1968, pages 678-679.*

See also: Joachim M.: "Statistiche Analyse der Werte von Φ_{F2}" — *Kleinheubacher Berichte*, Vol. **24** (1981), pages 253-257.

Predictions:

R_{12}****

Year \ Month	1	2	3	4	5	6
1982	121	119	117	114	112	110

**** *Data kindly supplied by Dr. A. Koeckelenbergh, Sunspot Index Data Center, Brussels.*

Estimated error in forecasts of R_{12} six months in advance: ± 9.

I_{F2}*****

Year \ Month	1	2	3	4	5	6
1982	152	149	145	142	138	(134)

***** *Data kindly supplied by the Science Research Council, Appleton Laboratory, Slough.*

The figure in brackets is the value predicted six months in advance.

Φ******

Year \ Month	1	2	3	4	5	6	7	8	9	10	11	12
1982	199	192	192	193	190	181	170	164	164	167	168	164
1983	157											

Φ_{F2}******

Year \ Month	1	2	3	4	5	6	7	8	9	10	11	12
1982	190	184	185	188	188	182	172	164	162	164	166	163
1983	157											

****** The prediction method elaborated within the CCIR Secretariat has, once again, been slightly modified since September 1979. The method was verified by comparison of measured and predicted data from October 1977 till the present time. A publication on these modifications will appear after verification of the method through several additional months.

Official Announcements

FINAL ACTS OF THE WORLD ADMINISTRATIVE RADIO CONFERENCE (GENEVA, 1979)

The Government of the **People's Republic of China** has approved the above-mentioned Acts.

VACANCY NOTICES

Circular letters which have been sent to all Members of the Union announce the following vacancies:

- a post of **head of section, grade G.7,** in the General Secretariat; entry on duty: as soon as possible (circular letter No. 457 of 15 January 1982; vacancy notice No. 1-1982 ITU; final date for submission of applications: 15 April 1982);
- a post of **assistant to the legal adviser, grade P.3,** in the General Secretariat; entry on duty: as soon as possible (circular letter No. 458 of 15 January 1982; vacancy notice No. 2-1982 ITU; final date for submission of applications: 15 April 1982).

Only applications forwarded through administrations can be taken into account; detailed applications with ITU personal history forms should be submitted to the General Secretariat of the ITU, Place des Nations, CH-1211 Genève 20 (Switzerland), not later than the final date mentioned above.

TECHNICAL CO-OPERATION

Recruitment of experts

Circular letters which have been sent to all Members of the Union announce the following vacancies:

- a post of **telecommunication adviser,** to be filled as soon as possible for 15 months, in the Department of Posts and Telecommunications of the Republic of Zaire. Duty station: Kinshasa (circular letter No. 455 of 14 January 1982; field vacancy notice TC 01/82 ZAI-565; final date for submission of applications: 6 April 1982);
- a post of **project co-ordinator/senior adviser in planning and organization of training,** to be filled in July 1982 for one year with possibility of extension, in the Telecommunications Corporation of the Hashemite Kingdom of Jordan. Duty station: Amman (circular letter No. 456 of 15 January 1982; field vacancy notice TC 02/82 JOR-565; final date for submission of applications: 9 April 1982).

Only applications forwarded through administrations can be taken into account: detailed applications with personal histories should be submitted to the General Secretariat of the ITU, Place des Nations, CH-1211 Genève 20 (Switzerland), not later than the final dates mentioned above.

CALENDAR OF ITU CONFERENCES AND MEETINGS

DATE	TITLE	PLACE
1982		
	International Telegraph and Telephone Consultative Committee (CCITT):	
26 January-3 February	Working Parties of Study Group I (Definition and operational aspects of telegraph and telematic services (facsimile, teletex, videotex, etc.))	Geneva
3-10 February	Plan Committee for Asia and Oceania	Manila
8-12 February	Working Party II/3 (Numbering, routing and interworking)	Geneva
10-13 February	TAS Group (Tariffs (Asia and Oceania))	Manila
17-25 February	Meeting of experts on ISDN matters of Study Group XVIII	Munich
9-16 March	Working Party VII/3 (Network interworking, switching and signalling)	Melbourne
9-26 March	Working Party VII/5 (Network aspects)	Melbourne
16-19 March	GAS 3 (Economic and technical aspects of the choice of transmission systems)	Geneva
17-19 March	Co-ordination Committee of the Plan Committee for Africa	Yaoundé
30 March-6 April	Working Parties of Study Group XV (Transmission systems)	Geneva
14-16 April	GAS 8—Authors	Geneva
19-21 April	GAS 8 (Economic and technical impact of implementing a regional satellite network)	Geneva
10-14 May	Working Parties VII/1 (Network service classes and facilities) and VII/2 (Network access interfaces)	Geneva
10-14 May	Working Parties II/1 (Operation and supplementary services) and II/2 (Human factors)	Geneva
11-14 May	GAS 4 (Primary sources of energy)	Geneva

DATE	TITLE	PLACE
11-14 May	Working Party RA/TV (Maintenance of sound programme and television transmissions) of Study Group IV (Transmission maintenance of international lines, circuits and chains of circuits; maintenance of automatic and semi-automatic networks)	Geneva
17-19 May	Working Party IV/1 (Maintenance of telephone-type circuits)	Geneva
17-21 May	GAS 5 (Economic and social problems relating to telecommunication development)	Rome
17 May-4 June	Working Parties of Study Group XI (Telephone switching and signalling)	Geneva
20-21 May	Working Party IV/3 (Maintenance organization)	Geneva
24-26 May	Working Party IV/2 (Measuring equipments)	Geneva
31 May-4 June	GAS 9 (Economic and technical aspects of transition from an analogue to a digital telecommunication network)	Geneva
1-4 June	Working Party "Directives" of Study Group V	Geneva
2 June	Working Party "Handbook on voice-ear measurements" of Study Group XII	Geneva
3-7 June	Working Party "Laboratory" of Study Group XII	Geneva
7-23 June	Working Parties of Study Group III (General tariff principles)	Geneva
8-11 June	Study Group XII (Telephone transmission performance and local telephone networks)	Geneva
10-22 June	Study Group XVIII (Digital networks)	Geneva
14-16 June	Study Group XVI (Telephone circuits)	Geneva
21 June-2 July	Working Parties of Study Group XI (Telephone switching and signalling)	Geneva
6-8 September	GAS 7 (Rural telecommunications)	Geneva
14-16 September	Co-ordination Committee of the Plan Committee for Europe and the Mediterranean Basin	Athens
21-23 September	CMBD (Circuit noise and availability)	Geneva
29 September-1 October	Working Party IV/5 (Maintenance of systems)	Geneva
4-6 October	Working Party IV/4 (Investigations and network maintenance handbook)	Geneva
5-15 October	Study Group IX (Telegraph networks and terminal equipment)	Geneva
18-22 October	Study Group XVII (Data communication over the telephone network)	Geneva
25-29 October	GAS 5 (Economic and social problems relating to telecommunication development)	Geneva
1-5 November	Working Parties II/4 (Traffic engineering, network planning, forecasting) and II/5 (Quality of service and network management)	Geneva
2-8 November	Working Party "Directives" of Study Group V	Geneva
8-19 November	TEUREM (Tariffs (Europe and the Mediterranean Basin))	Geneva
9-12 November	Study Group V (Protection against dangers and disturbances of electromagnetic origin)	Geneva
15-17 November	GAS 8 (Economic and technical impact of implementing a regional satellite network)—Authors	Geneva
15-18 November	Study Group VI (Protection and specifications of cable sheaths and poles)	Geneva

DATE	TITLE	PLACE
16-26 November	Study Group VIII (Terminal equipment for telematic services (facsimile, teletex, videotex, etc.))	Geneva
23 November-3 December	Study Group XV (Transmission systems)	Geneva
29 November-10 December	Study Group XI (Telephone switching and signalling)	Geneva
6-10 December	GAS 9 (Economic and technical aspects of transition from an analogue to a digital telecommunication network)—Authors	Geneva
7-17 December	Study Group VII (Data communication networks)	Geneva
	Joint Study Groups of the two CCIs:	
	CMBD (see under CCITT)	
	Plan Committees (see under CCITT)	
15-26 February	**CCIR XVth Plenary Assembly**	**Geneva**
19 April-7 May	**37th Session of the Administrative Council**	**Geneva**
23 August-17 September	**Regional Administrative Conference for FM sound broadcasting in the VHF band (Region 1 and certain countries concerned in Region 3)**	**Geneva**
28 September-5 November	**Plenipotentiary Conference**	**Nairobi**
1983		
26 October-1 November	**TELECOM 83**	**Geneva**

ITU Publications

The following letters indicate the languages in which documents are published:

F *for French*
E *for English*
S *for Spanish*
R *for Russian*
C *for Chinese*

Prices are in Swiss francs.

Note

A comprehensive list of all the publications of the Union will be supplied free on request by the ITU General Secretariat, Geneva.

Publications issued since the last number of the Journal

IFRB
International Frequency Registration Board

Tentative high frequency broadcasting schedule—March 1982—M(1982)

Period: 7 March-2 May 1982

Trilingual edition **F, E, S.**

CCITT
International Telegraph and Telephone Consultative Committee

VIIth Plenary Assembly, Geneva 1980

Yellow Book

Volume VI

Fascicle VI.4—Specifications of signalling systems R1 and R2. Recommendations Q.310-Q.490

(**F** = *ISBN 92-61-01082-2*
E = *ISBN 92-61-01081-4*
S = *ISBN 92-61-01083-0*)

Price: 40 Sw. fr.

Fascicle VI.7—Functional specification and description language (SDL). Recommendations Z.101-Z.104

Man-machine language (MML). Recommendations Z.311-Z.341

(**F** = *ISBN 92-61-01112-8*
E = *ISBN 92-61-01111-X*
S = *ISBN 92-61-01113-6*)

Price: 42 Sw. fr.

Volume VII

Fascicle VII.1—Telegraph transmission and switching. Recommendations of the R and U Series

(**F** = *ISBN 92-61-01132-2*
E = *ISBN 92-61-01131-4*
S = *ISBN 92-61-01133-0*)

Price: 59 Sw. fr.

Fascicle VII.2—Telegraph and telematic services terminal equipment. Recommendations of the S and T Series

(**F** = *ISBN 92-61-01142-X*
E = *ISBN 92-61-01141-1*
S = *ISBN 92-61-01143-8*)

Price: 59 Sw. fr.

Separate editions in **F, E, S.**

Forthcoming publications

Final Acts of the World Administrative Radio Conference (Geneva, 1979)

Separate editions in **R, C.**

Yearbook of common carrier telecommunication statistics (9th edition, chronological series 1971-1980)

Trilingual edition **F, E, S.**

List of fixed stations operating international circuits (List II) (10th edition, February 1979) (Supplements Nos. 8 to 14)

Trilingual edition **F, E, S.**

Manual for use by the maritime mobile and maritime mobile-satellite services (1982 edition)

Separate editions in **F, E, S.**

List of addresses (7th edition—December 1981)

Trilingual edition **F, E, S.**

List of international telephone routes (22nd edition, 1982)

Trilingual edition **F, E, S.**

Mobile services terminology (GLOS/3) (1981)

Trilingual edition **F, E, S.**

List of ship stations (List V) (22nd edition, 1982)

Trilingual edition **F, E, S.**

IFRB
International Frequency Registration Board

High frequency broadcasting schedules (quarterly)

Trilingual edition **F, E, S.**

Summary of monitoring information received by the IFRB

No. 211

Trilingual edition **F, E, S.**

International frequency list (10th edition, February 1979) (Supplements Nos. 8 to 14)

Preface

Separate editions in **F, E, S.**

Vols. I-Vd)

Multilingual edition **F, E, S, R, C.**

CCIR
International Radio Consultative Committee

Book of antenna diagrams (1981)

Separate editions in **F, E, S.**

CCITT
International Telegraph and Telephone Consultative Committee

Jointing of telecommunication cable conductors (1st edition, 1982)

Separate editions in **F, E, S.**

VIIth Plenary Assembly, Geneva 1980

Yellow Book

Volume I—Minutes and reports of the VIIth Plenary Assembly of the CCITT—Resolutions and Opinions issued by the CCITT—General table of Study Groups and Working Parties for the period 1981-1984—Summary table of abridged titles of Questions under study in the period 1981-1984—Recommendations (Series A) on the organization of the work of the CCITT—Recommendations (Series B) relating to means of expression—Recommendations (Series C) relating to general telecommunications statistics

Price: 59 Sw. fr.

Volume V—Telephone transmission quality. Series P Recommendations (Study Group XII)

Price: 35 Sw. fr.

Volume VI.1—General Recommendations on telephone switching and signalling—Interface with the maritime service. Recommendations Q.1-Q.119 (Study Group XI)

Price: 42 Sw. fr.

Volume VI.3—Specifications of signalling system No. 6. Recommendations Q.251-Q.295 (Study Group XI)

Price: 42 Sw. fr.

Volume VI.4—Specifications of signalling systems R1 and R2. Recommendations Q.310-Q.480 (Study Group XI)

Price: 40 Sw. fr.

Volume VI.5—Digital transit exchanges for national and international applications. Interworking of signalling systems. Recommendations Q.501-Q.685 (Study Group XI)

Price: 49 Sw. fr.

Separate editions in **F, E, S.**

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All documents ordered from the General Secretariat of the ITU must be paid for in advance. Documents must be paid for in Swiss francs when they are ordered.

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(Payment may also be effected by a cheque made out in another currency freely convertible into Swiss francs provided that the cheque, when cashed and converted, will cover the price of the publication in Swiss francs.)

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The prices quoted include packing costs and carriage by surface mail.

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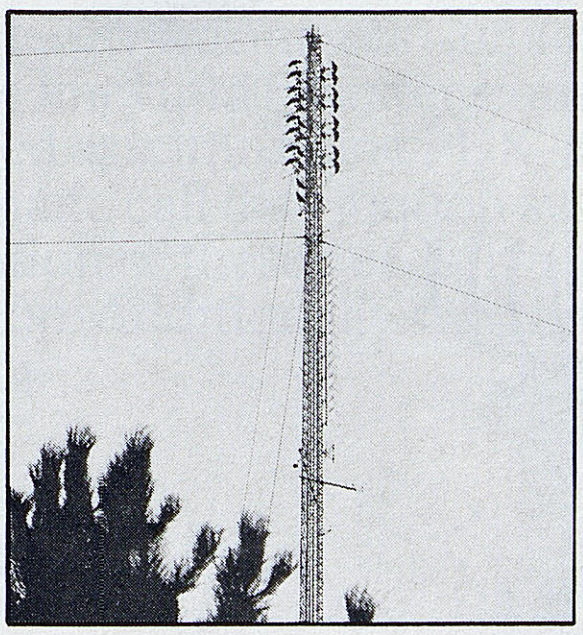

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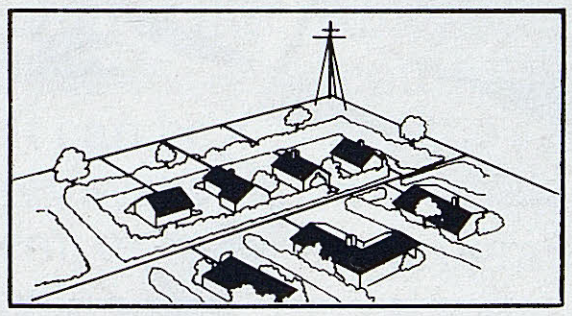

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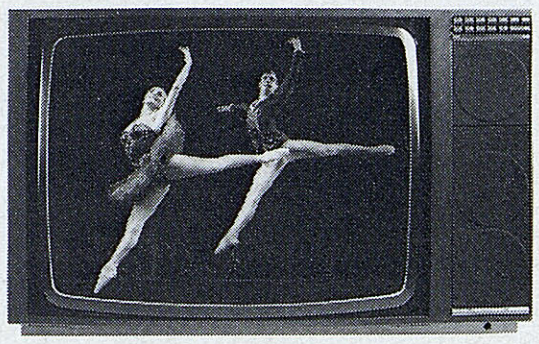

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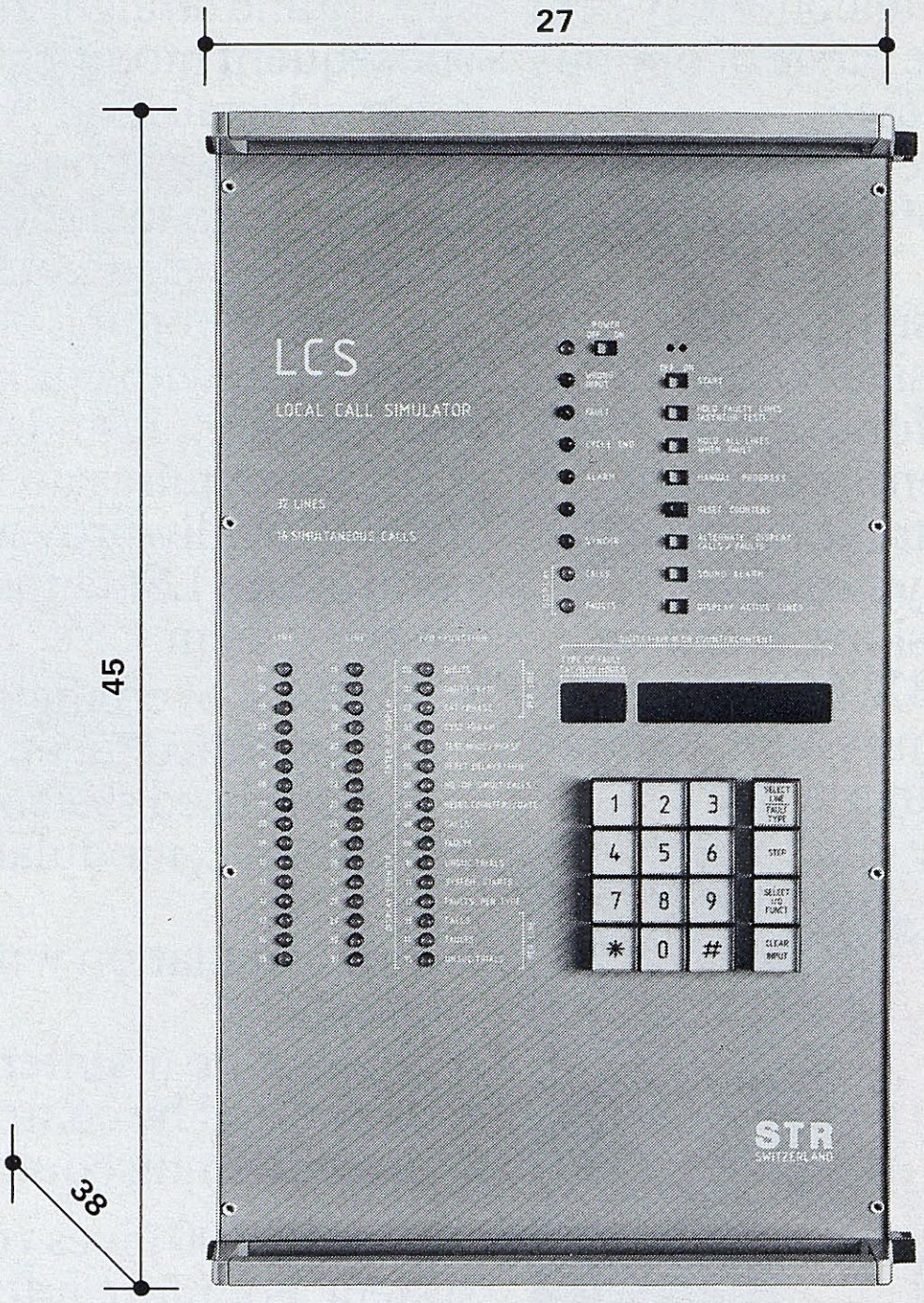

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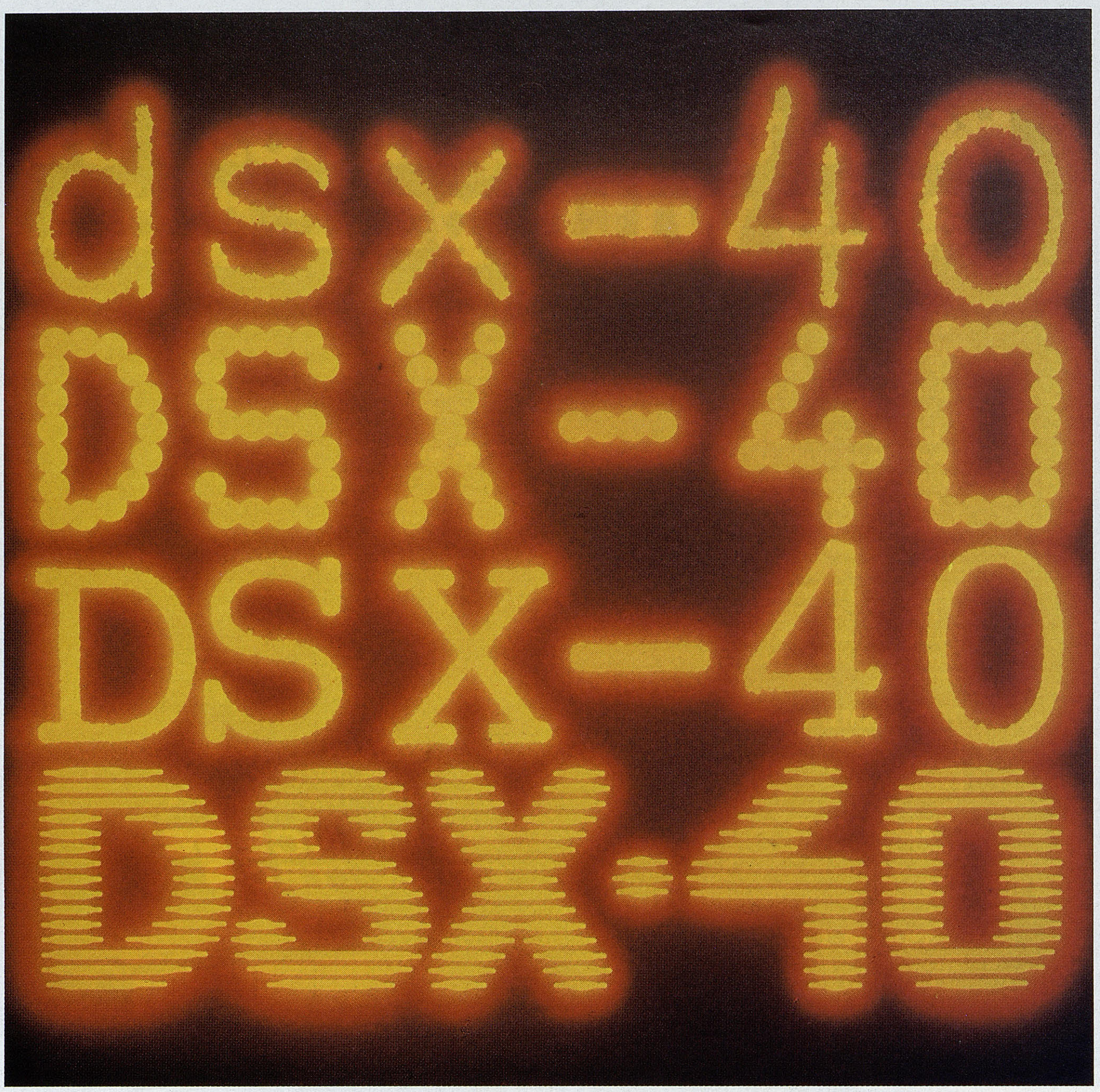

How can they communicate when they don't even use the same alphabet?

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Night traffic, dialog communication, PABX interface.

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Start by automating 2 or 3 telex lines.

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Further questions? We look forward to answering them at Philips Telecommunications, P.O. Box 32, 1200 JD Hilversum, the Netherlands. Telex 43712.

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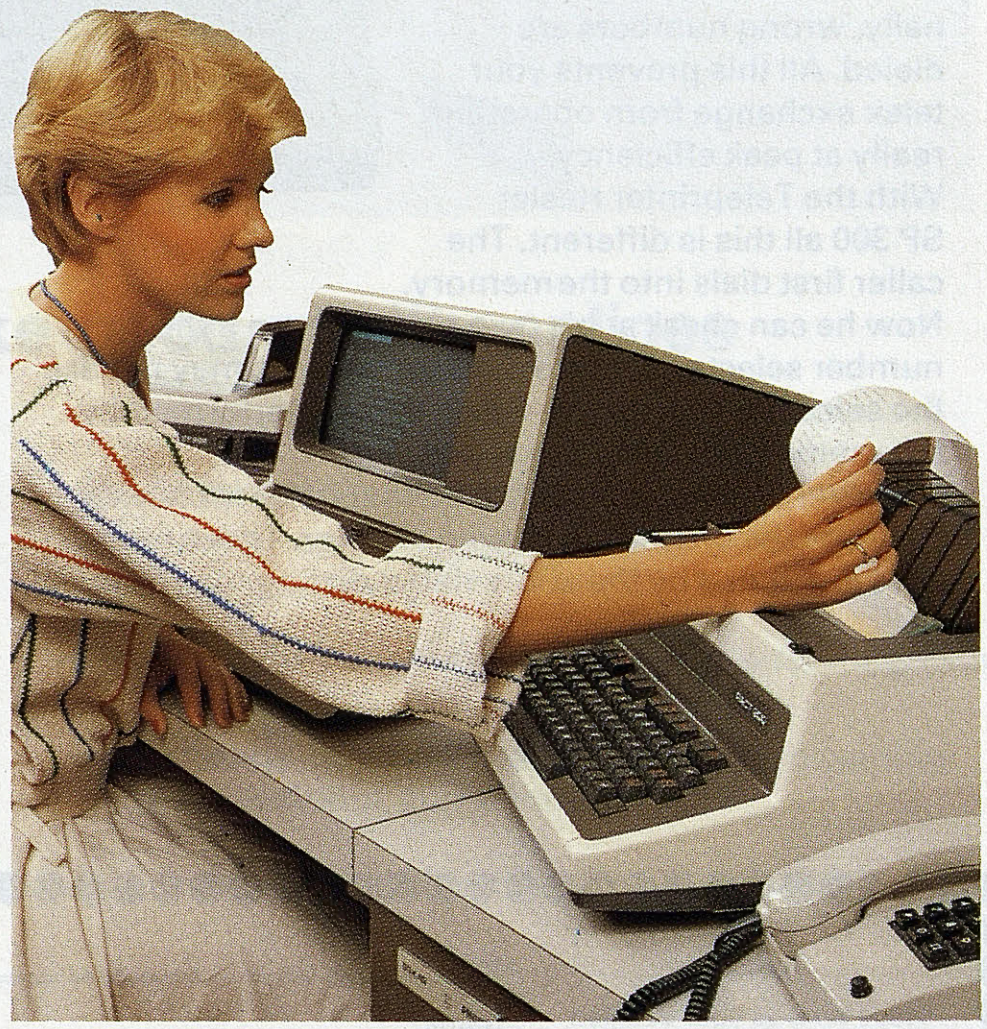

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If a number is busy, the dialing procedure is repeated at the simple touch of a key, the repeat key.
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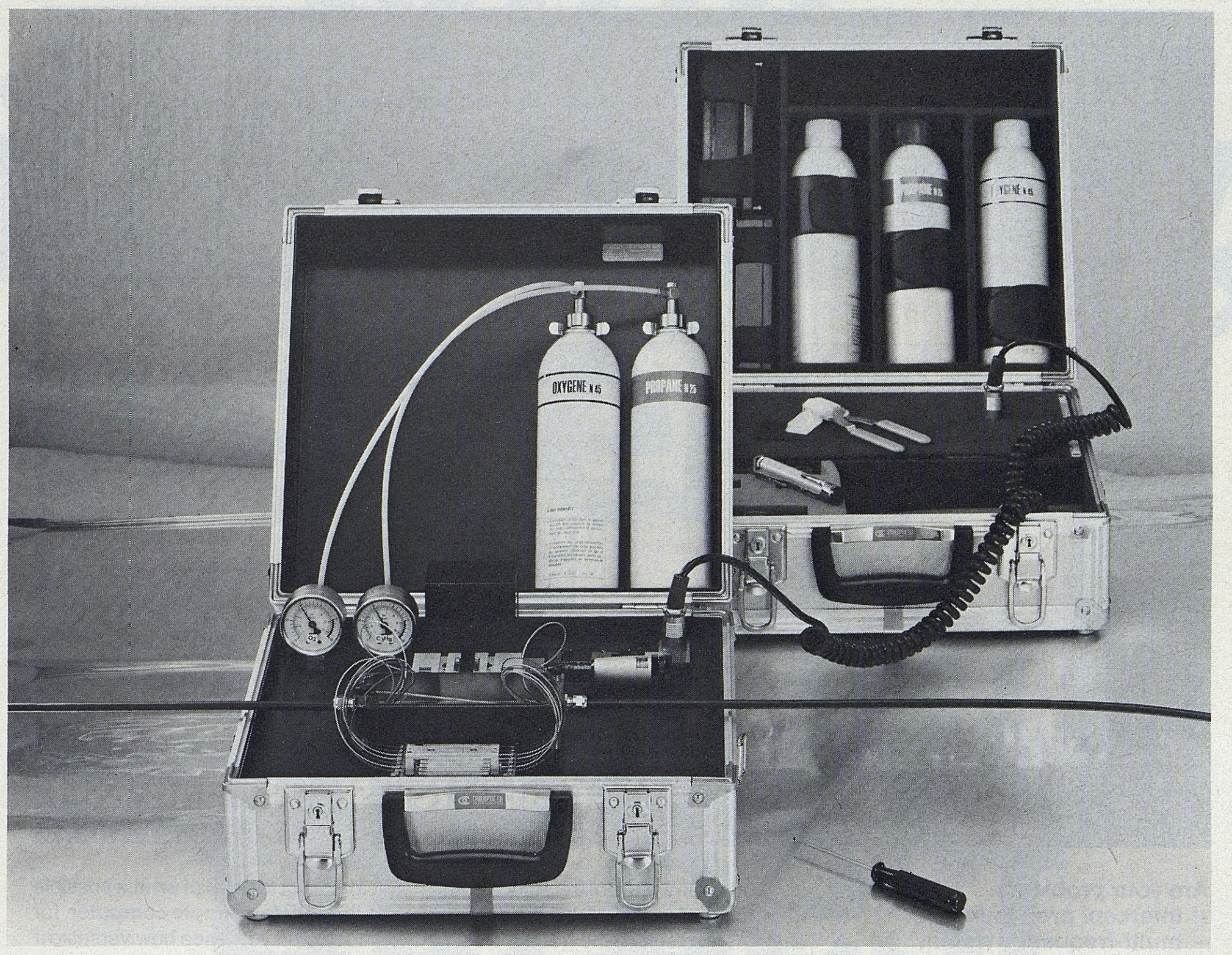
For optical fibres and cables...



...using a flame to make good quality splices

- Total autonomy for field use.
- Automatic centring eliminates need for precise mechanical alignment of fibres.
- Visual monitoring of joint quality throughout splice operation.
- Straight forward operation.
- **Very** small losses.
- Highly reproducible results without readjustments.
- Housing and resheathing problems elegantly solved.
- Already used by many leading companies and national authorities.

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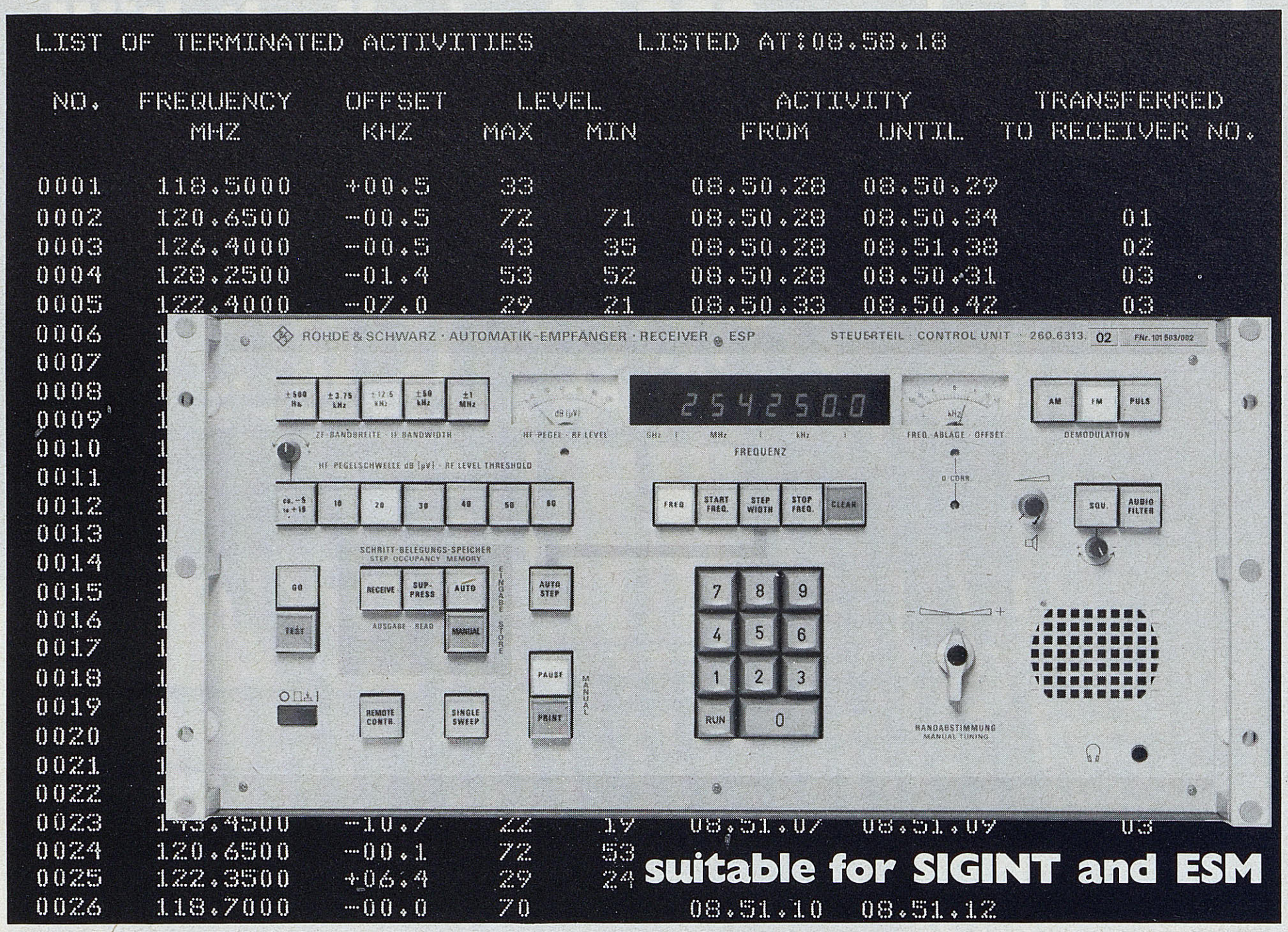
R&S radiomonitoring
Automatic receiver ESP



Are your problems
- **intercept probability,**
- **multi-frequency watch,**
- **high-speed channel access,**
- **busy-channel occupancy,**
- **accurate channel resolution?**

They're problems of the past, the processor-controlled, automatic receiver ESP masters them all; after all it was design-dedicated to the mission.

It searches any width of frequency band from **10 kHz to 2500 MHz** for signal activity and displays the frequencies it finds with level and offset from nominal frequency or feeds out the information all ready for a computer. **As many as 1000 frequency channels can be checked for occupancy in just one second.** And because it has built-in "intelligence" the ESP can handle a lot of tasks without a computer. Operation is easy – all the control settings are entered with lightup buttons with easy-to-understand labels. Link a simple, numerical tape printer to the ESP and you already have a complete **mini system.**

But that's not the end of what's possible – tie the ESP to a **simple computer,** for instance, and you'll see how versatile it can be in a full-scale radiomonitoring system.
We can also provide suitable antennas, slave receivers, direction finders and many other peripherals. There's **applications software** ready and waiting, and if you have **special needs** we'll customize the software for you.
Call or write to one of our 80 representatives worldwide – **an automatic receiving system can be cheaper than you think.**

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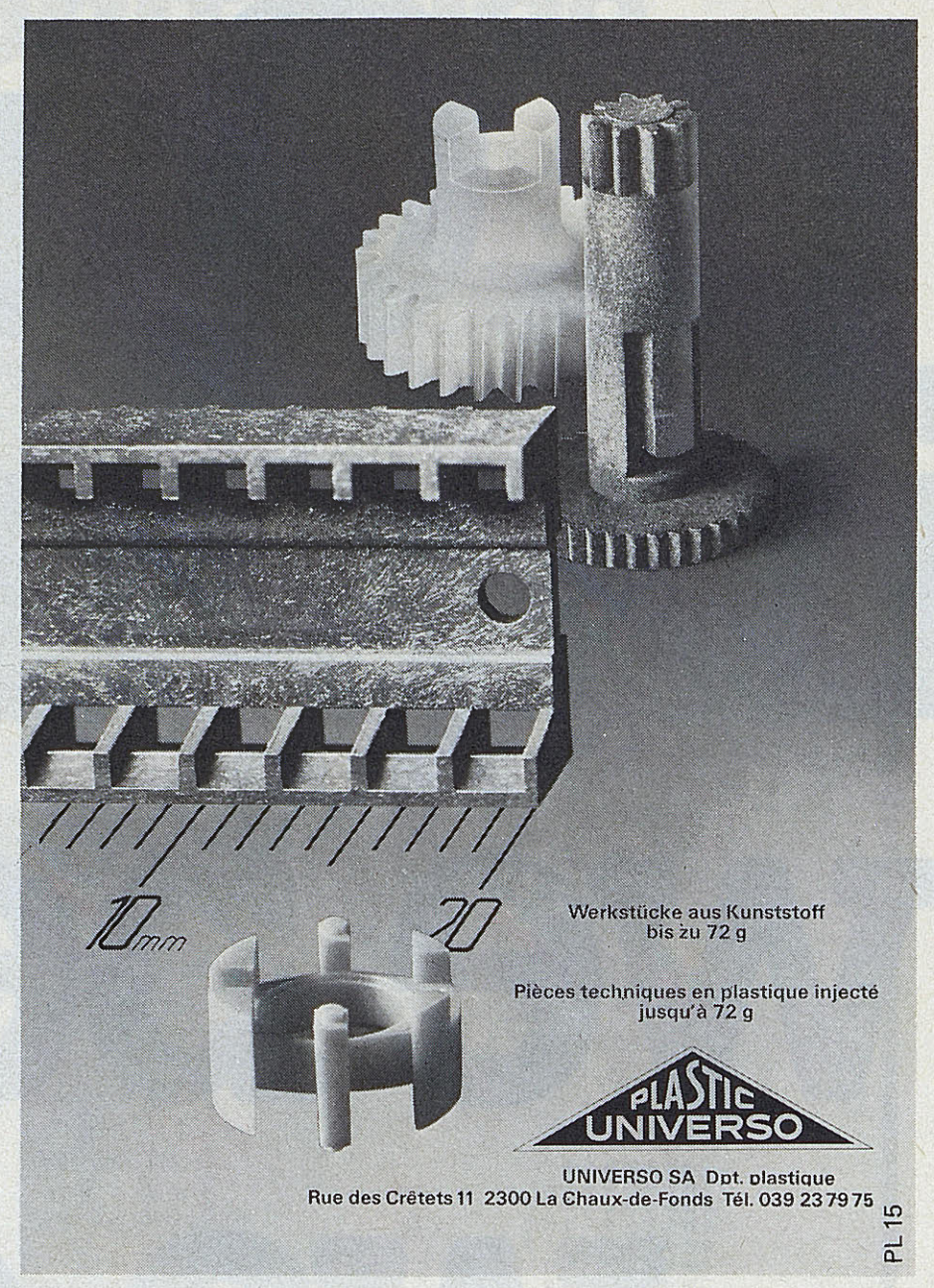


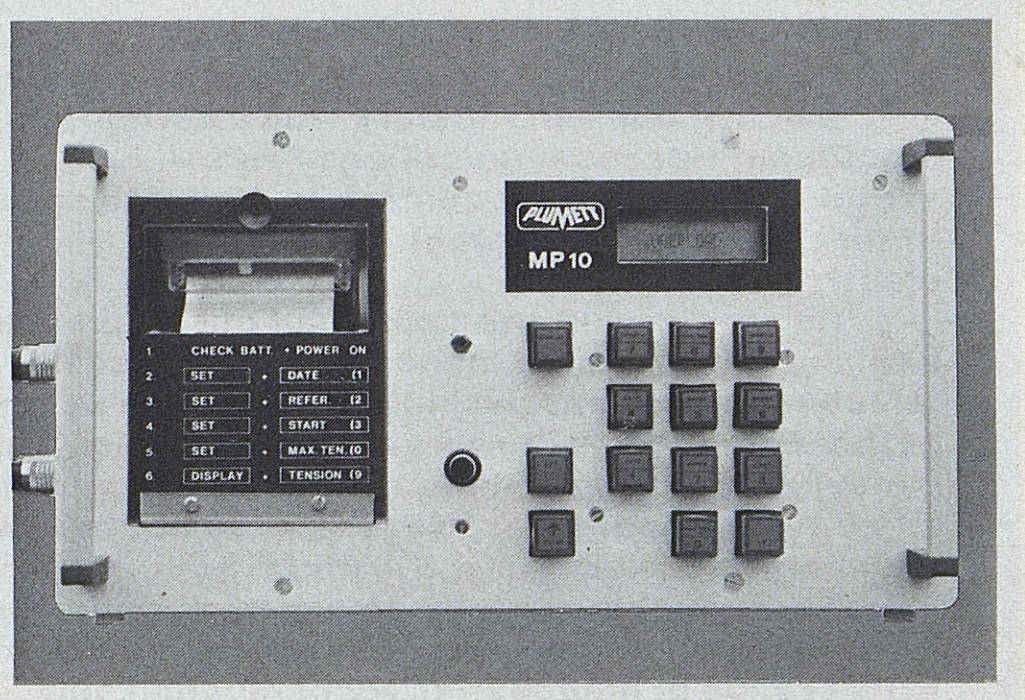
centro

Where two years ago there was only the desert, today there is Yanbu, to become the industrial city of the future.
The telephone/telex network, considered one of the most up-to-date in the world will be commissioned by SARTELCO, the Saudi Arabian subsidiary of SIRTI Italy.
Digital time divisions central office system will be interconnected with optical cables using SIRTI splicing and terminal connection technique.

PLUMETT – FIBRE OPTIC CABLE INSTALLATION

Our company establishment for specialized underground cable laying equipment is acknowledged world wide and for many years our research and development division have recognised the increasing interest in the fibre optic cable laying principal.

To facilitate a fast, safe and trouble-free cable laying process our extensive range of equipment has been enhanced by the highly accurate PLUMETT electronic model MP-10 monitor and recorder which provides the following key advantages:



1. application data programming and status call back capability
2. accurate recorder of cable pull and length
3. visual data print-out
4. failsafe overload control termination

This advanced electronic control underground cable laying monitor is for use with the PLUMETT range of automatic cable feeder equioment, including long cable lengths, also, special twin loop capstan winches for fibre optic installations.

We will, with pleasure, provide further specification, price and delivery information on request.

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Sirti

Gruppo IRI - Stet

Italian work for the development of telecommunications all over the world

For over a hundred years, Ericsson has been a major creative force in world telecommunications.

Much of our early history was a series of significant telecommunications firsts — in switching,in computer control, in digital techniques, in cable technology, in defence electronics.

As we grew up, we combined our skills, and became the confident managers of large-scale telecommunications projects. We became experts at the installation of turnkey telecommunications systems. We put in complete networks larger than any other company has ever installed outside its own home market.

Through this experience, we have developed a unique systematic approach, which straddles a broad range of managerial, technological and logistic disciplines — an approach which means that we complete the very largest project successfully, and on time.

We are a group with resources.

We have made outstanding progress.

ERICSSON

It is natural and beneficial for us to reflect these important achievements in a new group symbol. From January 1st, 1982, we will be known as Ericsson throughout the world. Our symbol is the word Ericsson, followed by a stylized E.

The name of the parent company, Telefonaktiebolaget L M Ericsson, remains unchanged however, as well as the names of a number of subsidiaries.

FOR THE TELECOM ADMINISTRATIONS

In public telecommunications systems, Ericsson's AXE digital system has had a success unparalleled in the history of telephony. AXE is unique — the only state-of-the-art switching machine with an extensive in-service-record. Its success is largely software-based: AXE software principles have been adopted as industry standard.

In the few years since it was launched, AXE-based telephone networks have been introduced in 33 countries. The AXE-based digital networks are designed to evolve into ISDN, the integrated services digital network. ISDN carrying both voice and data is unquestionably the future of world telecommunications.

FOR THE DEFENCE AUTHORITIES

In defence, the story is the same. In this high-technology field Ericsson has a reputation for brilliant individual achievements in communications, radar, infrared and laser equipment. Now we can offer increased capability in undertaking complete systems. We have developed our own systematic approach to such projects as the planning, supply and installation of strategic and tactical networks and air traffic control systems.

WE'VE GOT
FOR BETTER WAYS TO

FOR THE BUSINESS AND ADMINISTRATIVE WORLD

For business and administration, we are putting our proven capability in high-technology public telecommunications networks to use in business systems and office automation.

Already among the world's largest users and manufacturers of computers, we have acquired Datasaab, with its own expertise in business systems and terminals. We have combined this expertise with the skills of two Ericsson divisions already working on advanced private exchanges and information systems, and formed a new company — Ericsson Information Systems AB.

The formation of a US company, Anaconda-Ericsson Inc. is a significant step for the Group's development. Anaconda-Ericsson's major activity today is in cable manufacturing in the US and Latin America and the Anaconda-Ericsson Telecommunications Division is rapidly developing as a base for US marketing of Ericsson Information Systems products.

FOCUS ON SERVICE

Many important contracts today require network construction capability — not only for public telephone administrations, but also for business, industry, utilities and defence. In railway communications and signalling, communications and telemetry for pipelines too, Ericsson will undertake project management, installation and service for the most extended systems and networks.

Digital telecom systems and information systems are computer-based. Computers are hungry for specialist software. Ericsson has set up software houses offering consultancy, systems engineering, and project management — vital in a time of programmer scarcity.

FOCUS ON TECHNOLOGY

Underlying all networks, all equipment, is research and development. In the last two years alone, we have invested in excess of US$350 million in research and development to maintain our lead in technology. Optical fibre technology and the custom design of VLSI circuits are just two examples of Ericsson's research commitment.

DEVELOPMENT MEANS TRANSFORMATION

Development has transformed Ericsson. It is the same company, still a telecommunications leader. But it has developed, as telecommunications has developed; it is maturing, as the industry it belongs to is maturing.

As with any living thing, growing up means a change of style. Our own new style reflects the development of international operations on a new scale. We are proud of both.

A NAME COMMUNICATE

Telecommunications and information technology.

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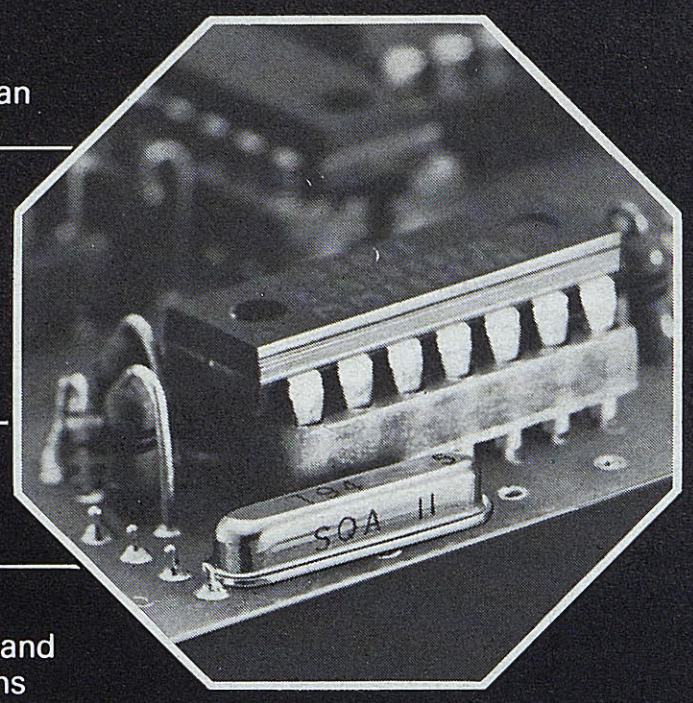

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To build up your contacts with those who count in world telecommunications advertise more in the "Telecommunication Journal".

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Designed, manufactured and installed by THOMSON-CSF, complete fiber optical cable transmission systems have arrived and represent one of the most impressive achievements of a rapidly growing technology.
These systems are bringing new ideas and stimulating the most advanced and up-to-date sectors of today's world:

Telecommunications

THOMSON-CSF creates switching station links: 30,000 calls are handled by a cable the size of a finger.
Note: THOMSON-CSF has installed the first optical link in Paris.

Data transmission

Even under difficult conditions, THOMSON-CSF transmits with utmost safety. Highlight: a fiber optical transmission systems can be installed adjacent to high voltage transmission lines.

Video

THOMSON-CSF fiber optical transmission systems have proved reliable and highly efficient in mass transit monitoring networks and "new service industry" applications. Just one of the jobs THOMSON-CSF has handled, visual monitoring of train operations on an electrified line.

In any sector and on any level, light transmits well when THOMSON-CSF is in charge.

Contact LTT
in charge of fiber
optical cables systems
for THOMSON-CSF

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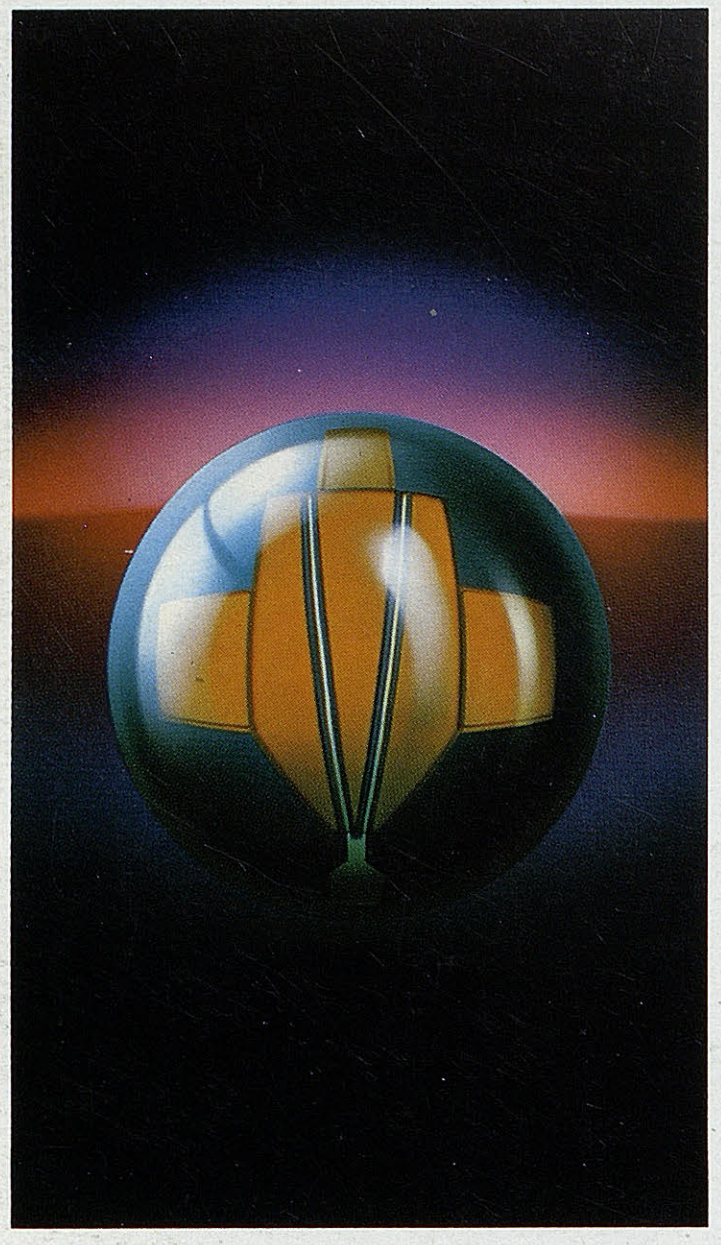

A modified testing specimen of Fujitsu's revolutionary new High Electron Mobility Transistor (HEMT). This GaAs-based device, which is 30 times faster than a conventional silicon transistor, is representative of the futuristic technology Fujitsu is developing to pioneer digital networks.

DIGITAL NETWORKS

Why Fujitsu is a leader

Fujitsu is one of the world's most innovative telecommunications companies.
Fujitsu is also Japan's number one computer maker.
And a leading developer of semiconductors and other microelectronic devices. With specialties like these, Fujitsu is ideally positioned to create digital telecommunications networks of unique design and scope. Which is just what it's doing. When you start thinking digital networks, you're thinking Fujitsu.

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